INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE NINETY-FIRST GENERAL MEETING of the Institution was held at the Royal Society of Arts on Tuesday, February 9th, 1926, Sir Thomas Holland (President) occupying the Chair.

The Secretary read the names of those who had been elected since the last meeting, as follows:—

Members.—Richard Henry Ames, Edwin Melhuish Bailey, F. Julius Fohs, Wallace E. Pratt, Paul Weaver, Alfred Wirth.

Associate Members.—Arthur Riley Bowen, Alexander Elson, Edward Leadbetter Gray, William Johnson.

REDWOOD MEDAL.—**The President** said that the Council had decided to award the Redwood Medal to Mr. C. H. Macarthy-Jones for his paper on "Electricity Applied to the Winning of Crude Petroleum, with Special Reference to the Yenangyoung Field, Burmah." The Students' Medal had been won by Mr. Ernest Clark for his paper on "Organic Theories of the Origin of Petroleum." The Council had considered it advisable, when a paper by one of the Student Members was suitable for the Medal, that that paper should be read before a General Meeting of the Institution.

ALTERATION OF BY-LAWS.—**The President** said the Council proposed to make certain suggestions for a revision of the By-laws. The question had been raised at different Annual Meetings. There were a certain number of changes which seemed to be desirable as a result of experience in the working of the Institution. Those alterations, before they could be made, must be read out at an Ordinary Meeting before being submitted to the Annual General Meeting. He asked the Secretary to read them so that the members might have time for full consideration, but the formal announcement would be made at the March Meeting.

The Secretary then read the proposed modifications in the By-laws.

The following Paper was then read :—

The Sulphur Compounds of Kimmeridge Shale Oil.

By FREDERICK CHALLENGER, D.Sc., Ph.D., F.I.C., JOHN HASLAM, M.Sc., A.I.C. (late Dalton Scholar of the University of Manchester), RANDLE JAMES BRAMHALL, B.Sc., and JAMES WALKDEN, M.Sc.

Dr. Challenger, in introducing the paper, said he greatly appreciated the courtesy of the Council of the Institution in allowing him, though not a member of the Institution, the opportunity of presenting his paper that evening. He would like to allude briefly to how he first came to take an interest in the problem. A year or so before the war, while he was on the staff of the Chemistry Department of the University of Birmingham, a course in organic chemistry, practical and theoretical, was planned for students who were engaged in studying for the degree or diploma in petroleum mining. This was done in collaboration with Prof. P. F. Frankland F.R.S., and Dr. C. K. Tinkler, and in consultation with Sir John Cadman. During various conversations which he had with members of the Mining Department at that time he was frequently told about the Kimmeridge shale-oil and the difficulty of rendering it suitable for future use, and still more about the fact that nothing was known concerning the nature of the compounds present. This was confirmed by various standard sources of information which he consulted. He then decided that whenever an opportunity should offer itself he would investigate the subject. The opportunity did not arrive for several years, but at the beginning of 1923 the investigation described in the paper was commenced.

The technical literature contains many references to the difficulty experienced in removing the sulphur compounds which are present in the crude Kimmeridge shale oil of Dorset.

So far as the authors are aware the numerous attempts to reduce the percentage of this undesirable element have been made without any knowledge as to the mode of combination of the sulphur. Although there is much to be said in explanation of this mode of procedure, it can hardly be considered as the one most likely to lead to satisfactory results.

The considerable success which was achieved in the removal of sulphur compounds from American petroleum long before their constitution was established is, as is well known, due to two main reasons. First, to the stable, saturated character of most of the hydrocarbons of which American petroleum is composed, and their consequent stability towards sulphuric acid. Second, to the relatively small content of sulphur compounds exhibited by most

American oils and by petroleums in general. The sulphur compounds of these oils are soluble in concentrated sulphuric acid probably, as would appear from the work of Mabery and of Thierry (B2,4,7,16), without chemical change since on dilution of the "acid sludge" they may be recovered.

In the case of shale oils the high percentage of unsaturated hydrocarbons greatly increases the loss during refining, since these compounds are readily soluble in sulphuric acid forming acid sulphuric esters, which are in many cases stable in presence of water and are subsequently lost. It has been shown by Heusler (C2) that neutral esters of sulphuric acid $SO_2(OC_nH_{2n+1})_2$ may be formed and under certain conditions may remain in the oil, actually causing an increase in its sulphur content. The elimination of sulphur dioxide, which is occasionally observed on distillation of "refined" oils, is probably due to the decomposition of these dialkyl sulphates (see also B1 and B6).

During the late war various papers dealing with the difficult problem of sulphur in shale oil were read before the Institution of Petroleum Technologists, and opinions were expressed by the authors, or by those who took part in the discussion, as to the nature of the sulphur compounds present. Owing, perhaps, to the exigencies of the situation at that time, no experimental evidence was submitted, and since then no further communications have been made on the subject. In his book entitled "Non-Benzenoid Hydrocarbons" (1922), Dr. B. T. Brooks, a fellow-student of one of the authors at the University of Göttingen, states that nothing is known as to the nature of the sulphur compounds of shale oil.

In the autumn of 1922 one of the present authors decided to attempt, not the desulphurisation of Dorset shale oil either on a laboratory or an industrial scale, but rather the identification of the sulphur compounds and their characterisation in the form of easily recognised derivatives. We are greatly indebted to the kindness of Mr. W. Hardy Manfield, who supplied us, through the Fusion Corporation of Middlewich, with several gallons of crude Dorset oil.

Before describing the chief results obtained in this investigation, it may be useful to indicate briefly the experience gained by other workers on the sulphur compounds of mineral oils up to the end of 1922. It will then be seen that the information actually accumulated was very considerable, and that, without any experimental work whatever, a survey of the literature would have yielded perhaps not definite conclusions, but certainly strong indications as to the nature of the sulphur compounds. It is, of course, obvious that the study of sulphur derivatives in coal tar must have a close bearing on the composition of those in shale oil.

The work of Victor Meyer (C1) established the presence of thiophen (1), and of its homologues in coal tar about 1885, while between 1891 and 1906 Mabery (B2,3,4,7) conducted extensive researches on the sulphur compounds of various American petroleums. He established, first of all, that dialkyl sulphides from methyl to butyl (2, 3) were present in the crude oil and in the sulphuric acid sludge produced during refinery treatment. Canadian oil yielded a series of compounds of the general formula $C_nH_{2n}S$, which Mabery designated as thiophanes. These compounds gave sulphones ($C_nH_{2n}SO_2$) on oxidation, and combined with ethyl iodide to form sulphonium iodides $C_nH_{2n}S{\cdot}C_2H_5I$. With mercuric chloride additive products were formed, but were not obtained in a condition suitable for analysis.

Although a whole series of these sulphides and the corresponding sulphones was prepared, their chemical constitution remained undecided. Their properties closely resembled those of the alkyl sulphides, but their physical properties were different, while their whole behaviour was entirely opposed to that of the true thiophen compounds.

Mabery considered them to be derivatives of polymethylene sulphides. It was not completely proved, however, that the tetrahydrothiophen or thiophane ring (4), or any ring system was present in any of these compounds, of which the lowest boiled at 125–130° and the highest at 290–295°. Some of them probably contained pentamethylene- and hexamethylene sulphide rings, or even open chain systems.*

This being the case, the use of the term thiophanes to designate a class of compounds of entirely unknown structure was perhaps somewhat unfortunate, but at that time much less was known concerning the properties and modes of characterisation of heterocyclic systems, and even at present the complete identification of all Mabery's compounds would probably involve years of work.

The recent syntheses effected by von Braun and Trümpler and by Grischkewitsch-Trochimovski (H4, H6) have again drawn attention to Mabery's conclusion that his thiophanes consisted of saturated ring systems containing sulphur.

These authors have synthesised trimethylene-, tetramethylene- (5) and hexamethylene sulphides, and many of their mono- and dimethyl derivatives (6), and have shown that as regards formation of mercuric chlorides, methiodides and (frequently liquid) sulphones, they closely resemble Mabery's thiophanes, of which, however, the simplest member contained six atoms of carbon.

In this connexion attention should be drawn to the work of Thierry (B16), published in December, 1925, who isolated methyl

* See discussion.

ethyl sulphide, tetrahydrothiophen and pentamethylene sulphide from a sulphuric acid sludge from Persian petroleum. These compounds were characterised as additive products with mercuric salts, or with methyl iodide, or as the sulphone (7). Thierry is continuing the research, and his results are particularly interesting as a corollary to those of Mabery* and to those described in this communication. It may be added that early in 1925 Birch and Norris (B15) isolated various aliphatic mercaptans from a low-boiling fraction of Persian petroleum.

Returning to a chronological survey of the subject, the detection by Boes (E2) of thionaphthen (8) in lignite tar oil, and of diphenylene sulphide (9) in coal tar, is of considerable interest, although published in a very inaccessible journal. The isolation of thiophen derivatives indicates the close relation existing between lignite- and coal tar- oils.

In 1917-18, Meyer and Meyer (G6) showed that under conditions possibly comparable with those existing in coal, shale or lignite retorts, the interaction of acetylene and hydrogen sulphide gave rise to many derivatives of thiophen, such as thionaphthen (8) and thiophthen (10). In the course of a somewhat similar investigation, Steinkopf (G8), from the products of the action of acetylene on pyrites, isolated thiophen and various methyl-, dimethyl- and ethyl-derivatives, several of which have been observed during the course of this research.

This being the case, it was not surprising that between 1915-19 Scheibler (A8) came to the conclusion that shale oils from the Tyrol and from the south of France contained derivatives of thiophen. His purification of the oils, involving repeated treatments with sodium or sodamide, and with magnesium methyl iodide seems unnecessarily complex, but he finally obtained fractions rich in sulphur which combined with mercuric chloride. From one of these fractions by treatment with acetyl chloride and aluminium chloride, he obtained a ketone containing sulphur. Analysis of the semicarbazone (11) indicated the possible presence of a propylthiophen methyl ketone (12), though the analyses agreed equally well with a methyl ketone derived from a trimethyl- or a methylethylthiophen. This established for the first time the presence of a thiophen derivative in a shale oil.

About the same time Weissgerber and Krüber (C8) isolated diphenylene sulphide and thionaphthen from coal tar.

* Most of the sulphides isolated by Mabery were obtained by dilution of the acid sludge resulting from the refining of the crude oil. In several instances the same products were obtained from the crude untreated oil, and although definite proof is lacking in some cases there seems little reason to doubt that all these sulphides were present before treatment with sulphuric acid.

In 1923 Pfaff and Kreutzer (E3) established the presence of 2-methylthiophen in a fraction of lignite tar oil by a method analogous to that employed by Scheibler. On treatment of the fraction with phosphorus pentoxide and acetyl chloride the resulting methylacetothienone (13) was analysed in the form of its phenylhydrazone.

In this connexion it may be mentioned that various authors (E3, D4) have referred to the fact that the presence of a large amount of unsaturated hydrocarbons interferes with the detection of thiophen derivatives by the indophenin reaction (isatin and sulphuric acid). This has been confirmed by the present authors, and may be responsible for various statements as to the absence of thiophen compounds from mineral oils.

In commencing the investigation it was decided to pay special attention to that portion of Kimmeridge oil which was volatile in steam, especially as the crude oil contained a certain amount of mineral matter (compare Marcusson and Picard, A20) which might be expected to facilitate decomposition during distillation under ordinary conditions. Up to the present there has been no occasion for the ordinary distillation of the crude oil, except on a very small scale.

About 30 per cent. of the oil was volatile with steam, and during this operation some hydrogen sulphide was evolved. When no more oil came over it was separated, and amines, phenols and traces of ketones removed by successive treatment with dilute hydrochloric acid (1 : 3), sodium hydroxide (10 per cent.) and saturated sodium hydrogen sulphite. Mr. J. J. R. A. Jinks and one of us have shown that this treatment does not affect the sulphur content of the oil (A22). The product thus purified was dried over sodium sulphate and distilled at atmospheric pressure until the temperature reached 180°, when the distillate was submitted to repeated fractionation at atmospheric pressure with an efficient column. The product of b.p. above 180° was similarly fractionated at 27 m.m. No sign of decomposition was observed below 180° and even the fractions boiling considerably higher than 200° could be distilled once or twice at atmospheric pressure without appreciable alteration. This behaviour is in marked contrast to that exhibited by the original crude oil when similarly distilled. Under such conditions hydrogen sulphide is evolved continuously. This would appear to be due to the decomposition of the high-boiling ingredients which are absent from the oil which has been distilled in steam.

The residue which was non-volatile in steam was extracted with ether, whereby a considerable amount of a black solid containing about 50 per cent. of mineral matter was removed, and the solvent

evaporated Up to the present this high boiling residue has received very little attention. The less volatile portion loses hydrogen sulphide even *in vacuo*, and only relatively very small quantities of wax-like solid m.p. 62-63°, which is free from sulphur, separate from the distillate. The isolation of a substance of similar m.p. is referred to by Blackburn (J. Inst. Pet. Tech., 1924, **10**, 175 Abs.).

The following fractions of the oil have been investigated up to the present:—

(i) —93°, (ii) 109°—117°, (iii) 117°—126°, (iv) 132°—140°, (v) 158°—167°, (vi) 105—115/27mm., (vii) 115—140/27mm.

From (i) thiophen has been obtained in very small amount in the form of its mercurichloride (14) and recognised by m.p., mixed m.p. and the indophenin reaction. In the case of (ii) a considerable amount of pure 2-methylthiophen has been obtained (15). On treatment of the fraction with mercuric acetate solution this is precipitated in union with the mercury salt, while the unsaturated hydrocarbons are mostly oxidised, giving rise to much mercurous acetate which constitutes a very large proportion of the deposit.

The nature of the oxidation products has not yet been determined. Much remains to be known concerning the action of mercuric acetate on unsaturated hydrocarbons.

On decomposing the mercuric acetate compound with hydrochloric acid, fairly pure 2-methylthiophen (15) was obtained. This was converted to the mercurichloride, which was purified by crystallisation (m.p. and mixed m.p.) and decomposed by hydrochloric acid yielding pure 2-methylthiophen. Its identity was established by analysis, by its physical properties, and by the formation and mixed m.p. determinations of the corresponding dithienyl derivative (16, analysis) and mercuribromide (17), and by the m.p. and analysis of the tribromo-compound.

By similar methods the presence of 2-ethylthiophen (18) and of 2 : 3-dimethylthiophen (2 : 3-thioxen) (19) has been established in the fraction of b.p. 132-140°. These products were isolated as mercurichlorides and checked by analysis and by conversion to the corresponding thiocyanates. Both these thiophen homologues were detected by Steinkopf (F_9) in the tar obtained by the action of acetylene on pyrites.

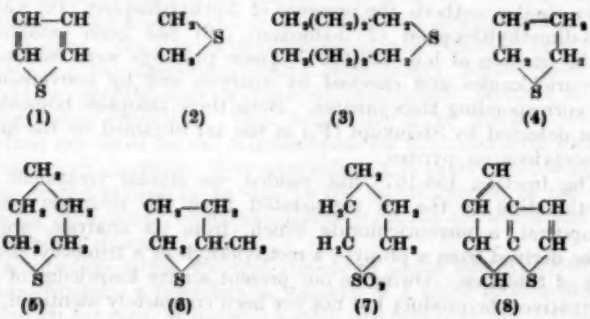
The fraction 158-167° has yielded, on similar treatment and fractionation of the oil regenerated from the mercuric acetate compound, a mercurichloride which, from its analysis, appears to be derived from a propyl-, a methylethyl- or a trimethyl-derivative of thiophen. Owing to our present scanty knowledge of such derivatives the product has not yet been completely identified.

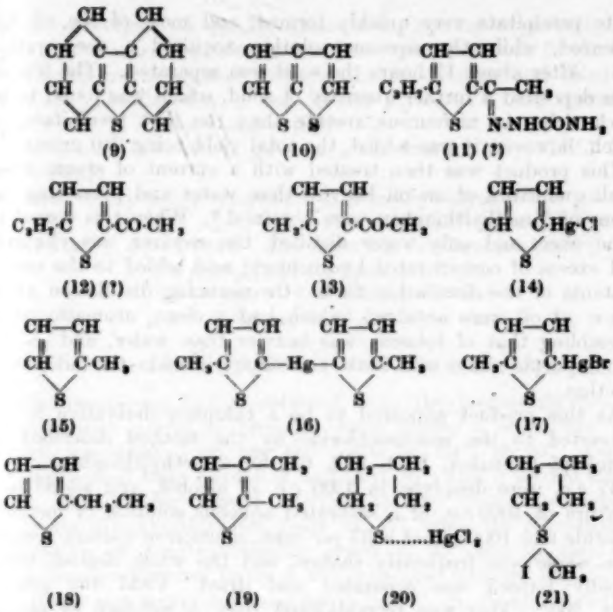
From the fraction b.p. 105-115° at 27 m.m. naphthalene and thionaphthen (8) have been obtained, by the successive use of picric acid and mercuric acetate, and characterised by means of the picrate and the sulphone respectively. It appears probable that thiophthen (10) may also be present in this portion of the oil, but this has not yet been definitely established.

The products described so far are derivatives of thiophen, but during the last few months the presence of tetrahydrothiophen (4) or tetramethylene sulphide, and probably of several similar derivatives, has been established. These substances are soluble in aqueous mercuric acetate and were overlooked at first. They can be obtained as the insoluble additive products with mercuric chloride by the addition of common salt to the filtrate obtained after removal of thiophen derivatives with mercuric actetate With aqueous mercuric chloride they react very rapidly, and in this way also may be separated from the true thiophen derivatives which combine more slowly with mercuric chloride.

Tetrahydrothiophen has been isolated from the fraction 109-117° as mercurichloride (20), as methiodide (21), (analysis), and as the mercuric iodide compound of the methiodide, and in spite of the small quantity available there seems to be no doubt as to its identity. Its whole behaviour, including its objectionable odour (see von Braun, H4), is most strikingly differentiated from 2-methylthiophen, which forms no methiodide. Its behaviour on oxidation agrees with that of the compounds described by Mabery and by Grischkewitsch-Trochimovski.

Structural Formulae of Compounds Referred to in the Theoretical Section of this Paper.





EXPERIMENTAL.

Identification of Thiophen in the Light Oil Fractions of B.P. 77-93°.

On treating about 15 c.c. of the fraction with alcohol, mercuric chloride and sodium acetate, the resulting precipitate contained much mercurous chloride. The alcohol-soluble portion on repeated crystallisation from alcohol and acetone gave a strong blue indophenin reaction, and was identified as thiophenmercurichloride by its m.p. and mixed m.p. (180-181°). It strongly depressed the m.p. of 2-methylthiophenmercurichloride.

EXAMINATION OF THE FRACTION OF LIGHT OIL OF B.P. 109-113°.

175 c.c. of the fraction of b.p. 109-113° at atmospheric pressure were added to a solution of 635 grams of mercuric acetate in 1800 c.c. of water, and well shaken at intervals during about an hour. A

white precipitate very quickly formed, and most of the oil disappeared, while the aqueous solution acquired a deep yellow tint. After about 1¾ hours the solid was separated. The filtrate soon deposited a further quantity of solid, which was found to be much richer in mercurous acetate than the first precipitate, to which, however, it was added, the total yield being 250 grams.

This product was then treated with a current of steam when small quantities of an oil heavier than water and possessing the odour of 2-methylthiophen were obtained.* When this ceased to come over, and only water distilled, the receiver was changed, and excess of concentrated hydrochloric acid added to the cooled contents of the distillation flask. On resuming distillation about 50 c.c. of oil were obtained, which had a clean, aromatic odour resembling that of toluene, was heavier than water, and gave a strong purple colour with isatin and sulphuric acid—the indophenin reaction.

As this product appeared to be a thiophen derivative it was converted to the mercurichloride by the method described by Steinkopf (Annalen, 1914, **403**, 63) for 2-methylthiophen.

57 c.c. were dissolved in 3300 c.c. of alcohol, and added to a mixture of 4000 c.c. of a saturated aqueous solution of mercuric chloride and 1000 c.c. of a 33 per cent. solution of sodium acetate. The whole was frequently shaken, and the white deposit which rapidly formed was separated and dried. Yield 169 grams; m.p. 200°. This was recrystallised from a mixture of alcohol and acetone. About 12 grams of an insoluble product were obtained which consisted partly of mercurous chloride. Three separate deposits were obtained from the alcohol-acetone: (*a*) sintered at 196° and melted at 200-201°; (*b*) showed practically no sintering and melted at 202°; (*c*) melted sharply at 200-201°. The mercurichloride compound appeared therefore to be homogeneous and almost pure, since 2-methyl thiophen mercurichloride is stated by Steinkopf (*loc. cit.*) to melt at 204° after previous sintering. The three deposits (123 grams) were united and again recrystallised, when finally 101 grams of a pure white product were obtained m.p. 200-202°:—

0·1140 gave 0·0474 AgCl; Cl = 10·29
0·1497 gave 0·1052 $BaSO_4$; S = 9·65
C_5H_4ClSHg requires Cl = 10·64, S = 9·60 per cent.

100 grams of the product were mixed with 200 c.c. of hydrochloric acid and 100 c.c. of water, and distilled in steam, when a

* The odour and density of this oil were entirely different from that of the original fraction. In view of later work it is probable that it consisted of unreacted oil very rich in 2-methylthiophen which was occluded in the large mass of the precipitate.

clear, colourless oil quickly came over, leaving a perfectly clear solution of mercuric chloride free from mercurous salt in the flask.

The oil was separated without the use of ether and dried over calcium chloride, when it had density $d_{24}^{24}=1\cdot017$. On distillation the whole of it came over within 0·3°.

A second distillation gave a main fraction b.p. 112·1-112·2, $d_{24}^{25}=1\cdot015$.

The corresponding constants of 2-methylthiophen are given as 112-113° (113°) and $d_{16}^{16}=1\cdot019$, while the 3-derivative has b.p. 114° at 738 m.m., $d_4^{15}=1\cdot0247$. The main fraction was analysed :—

0·1036 gave 0·2482 $BaSO_4$; S=32·91
0·1568 gave 0·3748 $BaSO_4$; S=32·83
C_5H_6S requires S=32·65 per cent.

Preparation of Tribromo-2-Methylthiophen.

The compound C_5H_6S obtained from the mercurichloride was shaken with excess of bromine water giving a crystalline mass which was drained on tile and found to melt at 85°. On one crystallisation from alcohol it had m.p. 87°, and a second deposit from the mother liquor melted at the same temperature. Tribromo-2-methylthiophen melts at 87°, while the corresponding derivative of 3-methylthiophen melts at 39° and in admixture with the 2-compound forms a non-separable mixture m.p. 75° :—

0·0917 gave 0·1540 AgBr and 0·0615 $BaSO_4$; Br=71·47; S=9·21
0·0592 gave 0·0992 AgBr and 0·0401 $BaSO_4$; Br=71·31; S=9·31
$C_5H_3SBr_3$ requires Br=71·64; S=9·55 per cent.

In the analysis of this substance the bromine and sulphur were determined by the Carius method, the sulphuric acid being precipitated from the filtrate after separation of the silver bromide.

Regeneration of 2-Methylthiophenmercurichloride.

One gram of the 2-methylthiophen obtained from the oil was treated with mercurichloride and sodium acetate. A fine crystalline product was quickly formed which melted at 203° without previous sintering. The mercurichloride of 3-methylthiophen melts at 138°.

Preparation of 2 : 2′-Dimethyl -5 : 5′-Mercury Dithienyl.

3·6 grams of 2-methylthiophenmercurichloride were dissolved in 300 c.c. of acetone and treated with a solution of 3·6 grams of sodium iodide in 45 c.c. of the same solvent. After standing overnight the precipitated sodium chloride was separated, the acetone evaporated and the residue crystallised twice from alcohol

m.p. 162-162·5°. Three further crystallisations failed to change the m.p. The product did not depress the m.p. of the dithienyl derivative prepared from synthetic 2-methylthiophen by Steinkopf's method :—

0·0978 gave 0·1197 $BaSO_4$; S = 16·79
$C_{10}H_{12}S_2Hg$ requires S = 16·25 per cent.

On treatment with mercuric bromide in acetone, according to the method of Steinkopf, this dithienyl derivative yielded 2-methylthiophen mercuribromide m.p. and mixed m.p. 178° on crystallisation from ethyl acetate.

PRELIMINARY EXAMINATION OF THE FRACTIONS OF LIGHT OIL OF B.P. 132-140° AT ATMOSPHERIC PRESSURE.

Three fractions were collected within this range, namely : (1) 132-134° ; (2) 134-138° ; (3) 138-140°, distillation being continued till no further alteration in the volumes occurred.

100 c.c. of fraction (2) of d_{17}^{17}=0·8894 were added to a solution of 280 grams of mercuric acetate in 1000 c.c. of water and the mixture well shaken. The solution became very yellow before any considerable amount of solid was formed, but after 30 minutes a thick paste began to separate, while the suspended oil, previously yellow, had become colourless. After 50 minutes a solid began to be deposited on the walls of the vessel as an adherent crust, apparently by crystallisation from the yellow solution. The mixture was then left for two days, being occasionally shaken, after which it was filtered. The precipitate, which contained much mercurous acetate, was then treated with a current of steam, when about 15 c.c. of oil was obtained. This was separated, dried and distilled (b.p. 134-139°). It had a sweetish odour, which was different from that of the original fraction, and had a lower density (d_{17}^{17}=0·8738), doubtless owing to the partial removal of the denser thiophen derivatives, although sulphur was still present. Further experience showed that this probably consisted of oil occluded in the bulky mercuric acetate compound rather than a product of its hydrolysis.

When no more oil came over from the main bulk of mercuric acetate compound, distillation was continued in presence of dilute hydrochloric acid (1 : 2), when about 30 c.c. of a yellowish oil were obtained. This was separated, dried over calcium chloride, and roughly fractionated twice from an ordinary distillation flask. Fractions 134-137° and 137-139° (d_{17}^{17} 0·9584) were obtained. The clean, relatively faint aromatic odour and the greatly increased density gave grounds for hope that a mixture consisting almost

entirely of thiophen homologues had been obtained.* The dimethylthiophen (thioxen) isolated from coal tar by Victor Meyer boiled at 136·5–137·5° and had density $d_{17·5}^{17·5}$=0·9755 (Die Thiophen-Gruppe, pages 51-2).

Conversion of the crude Thioxen to the Mercurichloride.—The two fractions of crude thioxen were mixed (17 grams) and added to a mixture of 1139 grams of alcohol, 1241 grams of saturated aqueous mercuric chloride and 255 grams of 33 per cent. aqueous sodium acetate. A white crystalline solid was soon deposited, and after 12 hours was separated (Deposit I.). The aqueous alcoholic solution on long standing yielded further quantities of solid of m.p. usually above 172°. The final deposits contained no sulphur. These products appeared to be complex mixtures, and their examination was deferred till larger quantities could be obtained.

Deposit I. was practically free from mercurous compounds. It sintered at 125°, and was completely melted at 130°. Recrystallisation from acetone showed it to be a mixture, and much time was lost in attempts to obtain a homogeneous product. Finally, after removal of a certain amount of a grey insoluble substance which blackened at about 150°, but was unmelted at 250°, the product was separated into two main portions of m.ps. ranging from 130-135° and from 140-145°.

Repeated crystallisation of the first raised the m.p. to 186-187° and portions of even higher m.p. were obtained. No definite product could be isolated. Similar treatment of the portion of m.p. 140-145° finally yielded products melting between 138° and 140°. These were mixed and, as the presence of the 2-mercurichloride of 3 : 4-dimethylthiophen was at first suspected, the product was treated with sodium iodide according to the method of Steinkopf (F11).

Conversion to the Mercuri-iodide.—0·4 gram was dissolved in 6 c.c. of acetone, and treated with a solution of 0·24 gram of sodium iodide in 4 c.c. of the same solvent. Sodium chloride was at once precipitated, and from the filtrate, on dilution with water, a white solid, m.p. 98° with slight previous sintering, was obtained. It appeared to decompose on attempting to recrystallise it. From the m.p. of this—possibly slightly impure product—the presence of 2-ethylthiophen -5-mercuri-iodide (m.p. 96-97°) may be inferred. The mercuri-iodide of 2 : 4-dimethylthiophen m.p. 137-139° would appear to be absent.

Behaviour of the mercuri-iodide m.p. 98° with Sodium Iodide.—0·2 gram in 7·5 c.c. acetone was mixed with 0·1 gram sodium iodide

* See page 128.

in the same solvent. The solution was filtered, evaporated, the residue treated with water and extracted with ether. Evaporation of the solvent left an oil which quickly solidified m.p. 55-61°.

A crude product of this melting point was obtained from synthetic 2-ethylthiophen mercurichloride and two molecules of sodium iodide, and also from a larger quantity of the same mercurichloride obtained from the shale oil. Recrystallisation of both products showed them to be mixtures. The m.p. rose to above 75°, but nothing homogeneous could be isolated. Both products contained halogen. (See page 121.)

Steinkopf (F13, p. 27) states that the dithienyl derivative cannot be obtained from 2-ethylthiophen -5-mercurichloride, which behaves abnormally with sodium iodide (2 mols.), the iodide alone being formed. The exhibition of the same abnormality by the mercurichloride from the shale oil is an indication of its derivation from 2-ethylthiophen. On the results of the preliminary experiments just described, it was decided to obtain a considerable quantity of the "crude thioxen" fraction from the crude mercuric acetate compound, and to submit it to a thorough fractionation in the hope of thereby facilitating the subsequent separation of the mercurichlorides by fractional crystallisation.

LARGE SCALE EXAMINATION OF THE FRACTIONS OF LIGHT OIL OF B.P. 132-140° AT ATMOSPHERIC PRESSURE.

140 c.c. of fraction (1) and 230 c.c. of fraction (2) were mixed and added to a solution of 860 grams of mercuric acetate in 3130 c.c. of water. The mixture was then stirred in a closed vessel for four days, filtered, and the precipitate washed with light petroleum to remove unchanged oil. (Dry weight of mercuric acetate compound 660 grams). On separating all the petroleum with a fractionating column and distilling in steam 90 c.c. of oil were recovered. This was then treated with 155 grams of mercuric acetate in 500 c.c. water, stirred for 12 hours, and the whole series of operations repeated. This time an oil, d_{17}^{17} 0·8367, was recovered.

When a further quantity (104 c.c.) of oil of b.p. 132-140° had been obtained by repeated fractionation of various residues, this was also converted into the mercuric acetate compound in a similar manner, and the unattacked oil again treated with mercuric acetate. The oil remaining unchanged after this second operation was extracted with light petroleum as usual, mixed with a similar product from a parallel experiment, and after a third and final treatment with the mercury salt, the portion which was still

resistant was collected and roughly fractionated. The main portion (42 c.c.) boiled from 134-140° and its density (d_{15}^{15}) was 0·8385, whereas that of the fraction (2) b.p. 134-138° (see page 116) was d_{17}^{17} 0·8894. Up to the present it has not been examined further. The mercuric acetate compound A (660 grams) containing much mercurous acetate was treated with a current of steam, and the small amount of oil which came over was added to that obtained from the light petroleum washings. On continuing the distillation after the addition of hydrochloric acid a considerable amount of oil was obtained of density d_{17}^{17} 0·9641.

As has been stated before, the recovered oil obtained from the light petroleum washings was submitted to further treatment with mercuric acetate. The precipitates obtained from parallel or comparable experiments were united and decomposed with hydrochloric acid as usual, when a further quantity of oil (d_{15}^{15}=0·9565) was obtained, and was added to that obtained from A above, when the resulting mixture had d_{15}^{15}=0·9633, after washing with sodium bicarbonate solution to remove acetic acid. This high value compared with that of fraction (2) b.p. 134-138°, page 116 (d_{17}^{17}=0·8894), showed that a very considerable concentration of the relatively dense thiophen derivatives had occurred.

This crude thioxen fraction was orange in colour, and was submitted to systematic fractionation, using an efficient column. After six operations no further alteration in the relative volumes of the fractions occurred, there being obtained :—

(i.) 133—135°	5·5 c.c.		
(ii.) 135—137°	47·5 c.c.	}	Faint aromatic odour like toluene
(iii.) 137—138°	45 c.c.	}	water-white in colour.
(iv.) 138—139°	3 c.c.		
(v.) Above 141°	10 c.c.		(Residue) Brown with unpleasant odour.

The densities of these final fractions have not yet been determined, but even after only two of the six operations the fraction of b.p. 135-136·5 had d_{15}^{15}=0·9678.

A preliminary experiment on the interaction of fraction (ii) with mercuric chloride, sodium acetate and aqueous alcohol showed it to be a mixture. Successive deposits of the mercurichloride had differing melting points, ranging from 110° in the case of the first to 165° with the third. The first deposit after two recrystallisations had the constant m.p. 143-144°, and did not appreciably depress the m.p. of the mercurichloride of 2-ethylthiophen. Recrystallisation of the later deposits raised their m.ps. to 190°, after which the quantity was too small for further crystallisation.

INVESTIGATION OF THE FRACTION OF CRUDE THIOXEN B.P. 135-137° ON A LARGER SCALE. DETECTION OF 2 : 3-DIMETHYLTHIOPHEN [illegible] OF 2-ETHYLTHIOPHEN.

The mercurichloride was prepared in two separate operations (A and B), using in each case 15 c.c. of the oil, 1050 c.c. of saturated aqueous mercuric chloride, 225 c.c. of 33 per cent. aqueous sodium acetate, and 1970 c.c. of 95 per cent. alcohol. These proportions were employed by Steinkopf (F13) in the case of 2-ethylthiophen.

In view of the results of the two preliminary experiments (p. 116) and the work of Steinkopf (F14) on the differing speeds of reaction of mercuric chloride with various homologues of thiophen, deposits were removed after suitable intervals of time, which were the same in each of the two parallel experiments :—

Time in hours	..	..	3	..	7	..	21
Melting point (A)	..	..	138—141°	..	126°	..	100°
(B)	..	..	142—143°	..	113°	..	100°

Judging from the m.ps. it would appear that deposits A and B might be expected to contain the largest proportion of the 2-ethylthiophen derivative. These were therefore united (18 grams) and recrystallised from hot alcohol, a very small amount of brown insoluble matter being left undissolved. The first crop of crystals had m.p. 158-162°, while 2-ethylthiophen -5-mercurichloride melts at 143°. On further crystallisation of this crop the m.p. rose continuously, and after six operations reached 208°, when it remained constant, being unaltered by further operations using first alcohol and then benzene.

0·0976 gave 0·0424 AgCl ; Cl = 10·06.
0·1354 gave 0·0904 HgS ; Hg = 57·53.
0·1222 gave 0·0814 HgS ; Hg = 57·45.
C_6H_5SclHg requires Cl = 10·21 ; Hg = 57·79 per cent.

The product so obtained gave no yellow colouration with sulphuric acid, but with isatin and sulphuric acid a green indophenin reaction was obtained. A trace dissolved in glacial acetic acid and added to a solution of phenanthraquinone in the same solvent gave, on addition of a little sulphuric acid, a deep blue colouration, turning bluish-violet on dilution with water. (Laubenheimer test.) Steinkopf (F13) gives the m.p. of 2 : 3-dimethylthiophen mercurichloride as 213-214°. The figures given for m.ps. in this communication are all corrected.

The mercurichloride of m.p. 208° was converted to the corresponding thiocyanate by the method of Steinkopf. The product obtained blackened at 202° without melting, as stated by that author. This affords further evidence of the identity of the mercurichloride of m.p. 208°. The mercurichlorides of the other three

dimethylthiophens all melt below 160°, while that of 3-ethylthiophen melts at 67-68°.

The mother-liquors resulting from the eight crystallisations just described were submitted to a long and tedious process of fractional crystallisation when, finally, about one gram of a product of constant m.p. 142-143° was isolated. In admixture with synthetic 2-ethylthiophen -5-mercurichloride (m.p. 142·5°) this melted at 142°. A much larger quantity of the same product was obtained on recrystallisation of deposits A_2, A_3, B_2, B_3.

0·1008 gave 0·0674 HgS; Hg=57·64.
0·0870 gave 0·0580 HgS; Hg=57·50.
C_6H_7SClHg requires Hg=57·79 per cent.

As a further check on the identification of this mercurichloride it was converted to the corresponding thiocyanate, which had m.p. 165° and mixed m.p. 164·5° with a synthetic specimen of 2-ethylthiophen-5-mercurithiocyanate of m.p. 165°.

It was not possible to prepare a pure dithienyl compound from the mercurichloride m.p. 142-3° and two molecules of sodium iodide, a further proof of its derivation from 2-ethylthiophen. (See page 118.)

Examination of Fractions of b.ps. between 158° and 167°.

A preliminary investigation was made of the fraction b.p. 158-162°. This had d_{19}^{19}=0·8931.

The mercuric acetate compound was prepared as usual from 100 c.c. of the oil, 280 grams of mercuric acetate and 1000 c.c. of water. After 3 days stirring the precipitate was separated, washed with light petroleum (unchanged and occluded oil, 30 c.c., being recovered from the washings) and treated with steam in neutral and then in acid suspension. Neutral distillation gave only about 2-3 c.c. of oil. The main bulk of oil was extracted from the (acid) distillate with ether, recovered and distilled, fractions (I.) up to 158°, (II.) 158-162°, (III.) 162-167° being collected. Fraction (II.) was by far the largest (15 c.c.) and had d_{19}^{19}=0·9306. It was again treated with mercuric acetate, and the oil regenerated from the precipitated solid, m.p. 211°, (now free from any mercurous salt) after the usual treatment. On distillation the main fraction (7 c.c.) had b.p. 158-159°.

Two grams were converted by the usual method to the mercurichloride, which melted at 136-138°, and after one crystallisation from light petroleum at 137-138°.

No additive product could be obtained from the regenerated oil (b.p. 158-159°) and methyl iodide. With isatin and sulphuric acid a brownish-red colour was formed.

The whole of the remaining fractions of shale oil boiling between 158° and 167° were converted to the mercuric acetate compound; 312 c.c. of oil, 890 grams of mercuric acetate, 2500 c.c. of 95 per cent. alcohol, and about an equal volume of water were employed, and the mixture stirred for about two days. Under these conditions the precipitate (670 grams) formed much more rapidly and was free from occluded oil. It was separated, washed and decomposed with hot dilute hydrochloric acid. The oil was extracted from the distillate with ether, and repeatedly fractionated till no alteration occurred in the relative volumes of the fractions (1) 157-158·5° and (2) 158·5-160°, which contained almost the whole of the product. The first fraction (3 c.c.) reacted remarkably slowly with mercuric chloride solution (193 grams) and sodium acetate solution (38 grams) in presence of 450 c.c. of alcohol. After two days the crystalline precipitate was separated (m.p. 138-139°). After one crystallisation from light petroleum it melted at 137·5-138·5°. The yield was very poor, even after several weeks, but gradually a further deposit formed, which is being investigated :—

0·1436 gave 0·0578 AgCl ; Cl = 9·95
0·0519 gave 0·0335 HgS ; Hg = 55·67
C_7H_7ClSHg requires Cl = 9·82, Hg = 55·54
C_8H_9ClSHg requires Cl = 10·21, Hg = 57·17
$C_9H_{11}ClSHg$ requires Cl = 9·35, Hg = 53·20

The mercurichloride appears from its m.p. to be identical with that obtained in the preliminary experiment and from the analysis must be a derivative of a propyl-, methylethyl- or trimethylthiophen. 2-*n*-propylthiophen mercurichloride melts at 155° and 3-*iso*-propylthiophen mercurichloride at 137°.

2 : 5-methylethylthiophen has been prepared by Steinkopf (b.p. 53-55° at 22 m.m.) (F13), but no mention is made of its mercurichloride, and from the behaviour of other 2 : 5-dialkylated thiophens it may be considered doubtful whether its preparation is possible by the usual methods, mercurous chloride and ill-defined products being obtained under these conditions (F14). From 2 : 5-dimethylthiophen, however, a mercurichloride was obtained by Steinkopf, its formation being preceded by that of a more complex additive product.

Examination of the "Naphthalene Fraction"—Isolation of Naphthalene and Thionaphthen.

150 c.c. of that fraction of the purified oil of b.p. 105-115° at 27 m.m. (210-230°, at atmospheric pressure) were treated with 17 grams of picric acid, when the pale yellow solid immediately became deep golden-yellow and formed a solid cake. The mixture was

warmed till solution was complete and then allowed to cool. The picrate was separated, freed from oil by suction, and the filtrate, which had darkened considerably, treated with a further 11 grams of picric acid, and the operation repeated till only picric acid separated on cooling. This was easy to determine from the shape and m.p. of the crystals, and from the fact that picric acid always separated from the dark liquid as an almost black solid, whereas so long as picrate formation occurred the deposit was golden-yellow in colour.

The united picrates were decomposed with excess of sodium carbonate solution in a current of steam. A colourless oil quickly distilled and partly solidified in the condenser. Weight, 9 grams. It had an odour resembling, but easily distinguishable from, that of naphthalene. The solid melted about 67°, and contained a sulphur compound. Eight grams were dissolved in about 30 c.c. of methylalcohol, and added to a solution obtained by dissolving 11 grams of mercuric oxide in 11 c.c. of glacial acetic acid and 90 c.c. of water, and adding 100 c.c. of methyl alcohol (Weissgerber and Krüber, C9). The mixture was heated under a reflux condenser for an hour and then filtered while hot. The insoluble residue, which contained some mercurous acetate, was mixed with excess of dilute hydrochloric acid (2 : 1) and distilled in steam. An oil came over which partially solidified at 0°, but was liquid at ordinary temperatures. It contained sulphur, but was obviously not pure thionaphthen. (In an earlier experiment on a very small quantity of material the oil thus obtained readily solidified in the condenser, contained sulphur, melted at 31° and appeared to be pure thionaphthen.)

In order, if possible, to detect the presence of this compound, the oil, m.p. about 18°, was dissolved in glacial acetic acid, and oxidised with hydrogen peroxide solution at 100°, according to the method of Weissgerber and Krüber (C9). On standing for some hours brownish yellow needles m.p. 139° were deposited. These contained sulphur, and after several recrystallisations from alcohol became white, had the constant m.p. of 143·5°, and did not depress the m.p. of an authentic specimen of thionaphthen sulphone prepared from pure thionaphthen m.p. 143°.*

0·1014 gave 0·1418 $BaSO_4$; S = 19·21
0·1000 gave 0·1387 $BaSO_4$; S = 19·05
$C_8H_8O_2S$ requires S = 19·31 per cent.

The methyl-alcoholic solution from which the mercuric acetate compound of thionaphthen had separated, deposited colourless

* This was very kindly provided by Drs. R. Fricke and G. Spilker, to whom the authors desire to express their best thanks.

plates on removal of the alcohol. These were identified as naphthalene by their odour, m.p. and the m.p. of the picrate.

The isolation of thionaphthen sulphone proves the presence of thionaphthen in the oil regenerated from the mercuric acetate compound, and hence in the fraction b.p. 105-115° at 27 m.m.

It was necessary, however, to determine the nature of the impurity which lowered the m.p. of the crude thionaphthen to about 18°, and which was probably responsible for the dark colour observed during oxidation with hydrogen peroxide.

0·6 gram of the crude thionaphthen was therefore reconverted to the picrate by treatment with an aqueous-alcoholic solution of picric acid. The product melted at 144°, whereas thionaphthen picrate has m.p. 149°. On repeated crystallisation from alcohol the m.p. was finally constant at 142·5°. According to Meyer and Meyer (C7) the m.p. of an equimolecular mixture of the picrates of thionaphthen and of thiophthen is 140-141°. Such a non-separable mixture was actually obtained by Meyer from the products of the action of acetylene on hydrogen sulphide (C6, G6).

The behaviour of the picrate with isatin and sulphuric acid, and the peculiar green fluorescence obtained from the picrate or the crude thionaphthen with sulphuric acid render probable the presence of thiophthen. This suggestion is supported by the fact that during the fractionation of the picrate an odour was observed which resembled that of thiophthen but was different from that of thionaphthen. The presence of thiophthen must not, however, be regarded as definitely established. Further experiments in this direction are in progress.

The amount of the fraction b.p. 105-115° which combined with picric acid was extremely small. The main bulk, which was inert to this reagent, was shaken with sodium hydroxide and distilled in steam. The sulphur content, about 6 per cent., was found to be almost unaffected. Further research must decide the interesting question as to the mode of linkage of the sulphur.

Detection of other Cyclic Sulphides in the Light Oil Fraction.

As has previously been mentioned (p. 111), that fraction of b.p. 109-113°, from which 2-methylthiophen was isolated, readily reacts with mercuric acetate, giving a large quantity of solid which may be twice the weight of the oil employed.

On treatment of the same fraction with a saturated aqueous solution of mercuric chloride, however, a white precipitate is

formed instantaneously but, while the speed of the reaction is much greater than with mercuric acetate, the amount of the deposit is very much smaller and its properties very different. On separation it is found to have a very unpleasant odour, which becomes more pronounced on standing and is very much stronger than that of the fraction which yielded it. The odour is accentuated by boiling with water or adding sodium hydroxide, when a precipitate of yellow mercuric oxide is produced. The mercury is therefore probably present in the form of a mercuric chloride additive product.

These properties sharply differentiate the substance from the mercurichloride of 2-methylthiophen, which contains mercury directly linked to a nuclear carbon atom, is stable to water and to sodium hydroxide, hot or cold, and does not develop an odour on standing. A trace of this substance was probably present, however, since the crude precipitate gave a slight indophenin reaction.

The whole of the deposit (18 grams, obtained from 150 c.c. of fraction 109-117°) was distilled with steam, when an oil with an intensely unpleasant odour was obtained. The aqueous distillate was extracted with ether, the extract well dried, and the solvent carefully removed using a good column. About 2 c.c. of a colourless oil remained. The amount was too small for fractionation, but it was divided into three portions.

From its odour and the b.p. of the fraction from which it was derived it appeared probable that either tetrahydrothiophen (b.p. 119°) ethyl propyl sulphide (b.p. 115-117°) or isopropyl sulphide (b.p. 121°) was present. Tetrahydrothiophen is stated by von Braun and Trümpler to have an extremely unpleasant odour (H4).

On mixing a portion of the oil with methyl iodide a solid was deposited in considerable amount. The product was washed on to a filter with methyl iodide, separated, and after two recrystallisations from alcohol formed white, shining needles which did not melt but sublimed sharply at 190°. It was odourless when dry, but during recrystallisation the odour of the sulphide was apparent. Water readily dissolved it, and the aqueous solution reacted at once with silver nitrate giving yellow silver iodide:—

0·1260 gave 0·1278 AgI; I = 54·83
$C_5H_{11}SI$ requires I = 55·21 per cent.

In alcoholic solution it reacted rapidly in the cold, or on warming with excess of mercuric iodide, giving yellow crystals which melted

about 114°. If the mercuric iodide was not in excess a white crystalline product was obtained. Tetrahydrothiophen methiodide sublimes at 190-195° (von Braun and Trümpler), and combines with mercuric iodide to form a yellow crystalline additive product m.p. 111° (Thierry, B16), while the mercurichloride melts at 124·5-126° (Thierry, Grischkewitsch-Trochimovski, B16, H6), and easily undergoes decomposition.

A further portion of the oil was added to saturated aqueous mercuric chloride giving an immediate white precipitate. The unpleasant smell disappeared, giving place to a faint odour resembling that of toluene. This was probably due to a trace of methylthiophen in the original crude mercurichloride. The product was recrystallised twice from alcohol, during which process the odour of the sulphide was again very pronounced, and obtained as long glittering needles m.p. 125-126°. These were immediately decomposed by sodium hydroxide and gave no indophenin reaction.

0·0622 gave 0·0398 HgS ; Hg = 55·16.
$C_4H_8SeI_4Hg$ requires Hg = 55·78.

A third portion of the crude tetrahydrothiophen was mixed with a little water, cooled in ice and treated with aqueous 3 per cent. potassium permanganate solution until the colour was permanent, and only a very faint odour remained. The excess of the reagent was removed by adding a few drops of alcohol and warming on the steam bath when the precipitated manganese dioxide was separated and washed. The filtrate was extracted three times with chloroform, the extract dried first over calcium chloride, then evaporated, the residue dissolved in ether and dried with sodium sulphate. On removing the solvent the slight oily residue became covered with a slight skin at 0°, and when cooled to –8° most of the oil solidified in long needles when rubbed, which melted again on removal from the freezing mixture. Grischkewitsch-Trochimovski states that the sulphone of tetrahydrothiophen melts at 8-10°. The product is being further investigated.

The alkaline solution remaining after extraction with chloroform contained a little potassium sulphate. This may have arisen by further oxidation of the sulphone or from traces of methylthiophen in the crude tetrahydrothiophen. On evaporation and acidification a strong odour of butyric acid or a similar fatty acid was noticed. Alcohol and sulphuric acid gave a pine-apple odour resembling that of ethyl butyrate. The production of a fatty acid is probably due to rupture of the tetrahydrothiophen ring.

Examination of Fraction 117-126° for Sulphides Other than Thiophen Derivatives.

When 70 c.c. of this fraction were mixed with 800 c.c. of saturated aqueous mercuric chloride and 350 c.c. of alcohol an immediate precipitate was obtained. After 3 hours the yield was 13 grams, and overnight a further 1.5 grams separated. The total yield was distilled with steam, giving a small amount of a colourless oil with an unbearable odour.

A few drops of this distillate gave an immediate white precipitate with mercuric chloride, but nothing with a solution of mercuric acetate. On addition of sodium chloride solution, however, a crystalline deposit was at once obtained. This experiment is worth recording since, owing to their non-reactivity or formation of soluble derivatives with mercuric acetate, the relatively small amounts of these evil-smelling sulphides were overlooked during the isolation of 2-methylthiophen (page 111).

On oxidising a portion of the distillate with potassium permanganate as before, an oil was obtained which had a bitter taste and was somewhat viscous at −10°, but could not be caused to solidify. (Grischkewitsch-Trochimovski, H6.)

The sulphide product obtained from this fraction is probably a mixture and is reserved for further investigation, so far as the minute amounts available will allow.

Presence of Other Sulphides in the Fraction b.p. 132-140°.

The yellow aqueous filtrate obtained after the separation of the mercuric acetate compound from this fraction (see page 118) was treated with a strong solution of sodium chloride till a heavy yellowish-white precipitate ceased to form. This was separated, washed and treated with a current of steam when a small quantity of oil came over which possessed an unpleasant odour resembling, though less pronounced than, that of tetrahydrothiophen. It reacted at once with aqueous mercuric chloride, giving a white crystalline solid of sharp m.p. 137–138° on recrystallisation, which gave no indophenin reaction. This may possibly be a derivative of pentamethylene sulphide which boils at 141·5° at 747 m.m., and gives a mercurichloride m.p. 137·5°, but further investigation is required in this connexion.

When no more oil came over hydrochloric acid was added and the distillation continued, a much larger amount of oil of very different odour being obtained.

The insoluble residue in the flask contained resin and much mercurous chloride.

Detection of Thiophen Derivatives in the Oil Obtained by Distillation of a Yoredale Shale from Derbyshire.

About 38 lb. of the shale were distilled from a small horizontal iron retort of the type recommended for laboratory use by Tinkler and Challenger (The Chemistry of Petroleum and its Substitutes. Crosby Lockwood. London. 1920 p. 188.) In spite of good condensing apparatus the yield of oil was extremely small (122 c.c.), as was to be expected from the stony appearance and non-inflammability of the shale which, nevertheless, had a decidedly bituminous odour when freshly broken. Considerable quantities of hydrogen sulphide were evolved during the heating process, steam being passed through the retort as soon as distillation commenced. The density of the crude oil, separated from water was 0·88 at 17°. It contained after drying 3·16 per cent. of sulphur. On distillation with steam about 60 per cent. was volatile. This was freed from bases and phenols, and roughly fractionated with a small column. The fraction 100-115° was treated with excess of mercuric acetate, and the precipitate, which consisted mostly of the mercurous salt, was decomposed with dilute hydrochloric acid in a current of steam. A trace of oil with a clean aromatic odour distilled. With sodium acetate and mercuric chloride this gave a minute white precipitate. The quantity was not sufficient for a m.p. determination, but it readily gave a strong blue indophenin reaction with isatin and sulphuric acid, thus clearly demonstrating the presence of thiophen derivatives in the original oil.

It would therefore appear that thiophen or its derivatives may reasonably be expected in all shale oils which contain sulphur. This is in agreement with the work of Scheibler (A 8), who obtained thiophen derivatives of similar type from shale oils of different origin.

The presence of naphthalene and thionaphthen could not be detected in the Derbyshire shale oil, but a picrate was readily formed by the fraction b.p. 210-230°.

The authors are much indebted to Professor A. Lapworth, F.R.S., for the facilities which he has provided for this investigation, and to Mr. J. R. A. Jinks, M.Sc., for most valuable assistance in the preliminary stages of the work.

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SULPHUR COMPOUNDS AND CERTAIN OTHER INGREDIENTS OF MINERAL OILS.

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4. Mabery. *Ibid.*, 1894, **16**, 92; 1906, **35**, 404. The sulphur compounds and unsaturated hydrocarbons of Canadian petroleum. Isolation from acid sludge obtained from the oil and sulphuric acid, of numerous sulphides C_nH_mS giving sulphones with potassium permanganate, but no sulphonic acid. With ethyl iodide and mercuric chloride additive products were obtained. Molecular refractions determined and found to be too high for the presence of thiophen rings. These sulphides designated "Thiophanes," but the presence of a 5 or 6 or 7 carbon ring not excluded. No attempt made to open the ring and identify the product.

5. Edeleanu and Filiti. *Bull. Soc. Chim.*, 1900, **23**, 384. Possible occurrence of thiophen derivatives in Roumanian petroleum.

6. Heusler and Dennstedt. *Z. für angew. Chem.*, 1904, **17**, 264. Alkyl sulphates in (refined) petroleum.

7. Mabery. *J. Amer. Chem. Soc.*, 1906, **28**, 419, 426. Composition of American petroleum. Brief references to behaviour on oxidation of the sulphur compounds in Californian oil and to the "stability" of those in Texas, Ohio and Canadian oils.

8-9. Siegfried. *Petroleum* **7**, 1320; Gurwitsch, *Z. für angew. Chem.*, 1913, **26**, 377. A petroleum with 10 per cent. of sulphur which falls to 2·5 per cent. on distillation *in vacuo*.

10. Smelkus. *Mitth. Mat. Pruf. Amt. Berlin-Dahlem*, 1922, **6**, 303. Ester of an acid containing sulphur in Montan wax.

10a. Dunstan and Brooks. *J. Ind. Eng. Chem.*, 1922, **14**, 1112. Failure of usual methods for removing sulphur from petroleum oils when sulphur present otherwise than as mercaptans, disulphides or carbon disulphide. Sulphuric acid refining of unsaturated oils may lead to production of alkyl sulphates.

11. Easterfield and McClelland. *J. Soc. Chem. Ind.*, 1923, **42**, 936. New Zealand mineral oils almost free from sulphur.

12. Waterman and Heimal. *Chem. Weekblad*, 1924, **21**, 374; *J. Inst. Petr. Techn.*, 1924, **10**, 812. Possible absence of thiophen from Persian oil. Action of sodium hypochlorite on typical sulphur compounds.

13. Wood, Lowy and Faragher. *J. Ind. Eng. Chem.*, 1924, **16**, 1116. Desulphurising action of sulphuric acid and of aluminium chloride on alkyl mercaptans, sulphides and disulphides, and on thiophen.

14. Dunstan. *J. Inst. Petr. Techn.*, 1924, **10**, 57. The crude oil of Maidan-i-Naftun. The sodium hypochlorite method of desulphurisation.

15. Birch and Norris. *J. Chem. Soc.*, 1925, **127**, 898, 1934. The occurrence of sulphur compounds in the light distillate from the crude oil of Maidan-i-Naftun. Alkyl mercaptans which yield disulphides during refining. Action of sodium hypochlorite on sulphur compounds of the type found in petroleum distillates.

16. Thierry. *J. Chem. Soc.*, 1925, **127**, 2756. Examination of oil obtained by dilution of sulphuric acid sludge from Persian petroleum. Detection of methyl ethyl sulphide, tetrahydrothiophen and pentamethylene sulphide.

17. Cadman. *J. Inst. Petr. Tech.*, 1925, **11**, 487. Origin of hydrogen-sulphide in natural gas, probably due to interaction of hydrocarbons with calcium sulphate. Conclusion based on laboratory tests.

18. Waterman, Perquin and Bogoers. *J. Soc. Chem. Ind.*, 1925, **44**, 621B. Desulphurisation of mineral oil distillates by means of silica gel.

19. Dunstan, Thole and Remfry. *J. Soc. Chem. Ind.*, 1924, **43**, 180. Refining and desulphurisation with bauxite.

Section C.

Sulphur Compounds in Coal Tar.

1. Victor Meyer. "Die Thiophen Gruppe" (Vieweg und Sohn, Braunschweig, 1888). Full account of isolation of thiophen and homologues from coal tar. Syntheses described. Complete summary of earlier work. Bibliography up to 1888.

2. Heusler. *Ber.*, 1895, **28**, 491, 498. Formation of neutral sulphuric esters, which may remain in oil, from sulphuric acid and unsaturated hydrocarbons of coal tar oils.

3. Boes. *Apotheker Zeit.*, 1902, **17**, 638. Isolation of diphenylene-sulphide from coal tar.

4. Meyer and Meyer. *Ber.*, 1918, **51**, 1575, 1587. Unsuccessful search for thionaphthen in coal tar.

5. Capelle. *Bull. Soc. Chim* (4), 1908, **3**, 150. Probable formation of thionaphthen from acetylene and sulphur.

6. Meyer and Weeche. *Ber.*, 1917, **50**, 423, 431. Formation of thiophthen and thionaphthen from acetylene, coal gas or methane and hydrogen sulphide.

7. Meyer and Meyer. *Ber.*, 1919, **52**, 1249. Behaviour of thionaphthen picrate in admixture with picrates of naphthalene and thiophthen.

8. Weissgerber and Krüber. *Ber.*, 1920, **53**, 1566. Isolation of diphenylene sulphide from coal tar.

9. Weissgerber and Krüber. *Ber.*, 1920, **53**, 1552. Occurrence of thionaphthen in coal tar, isolation as picrate, mercuric acetate compound, and sulphone.

10. Weissgerber. *Brennstoff-Chem.*, 1921, **2**, 1. *Central Blatt*, 1921, II., 709. Isolation of two methylthionaphthens from coal tar.

11. Anwers and Kohlhaus. *J. für prakt. chem.*, 1924, **11-12**, 331. Discussion of structure of one of these methylthionaphthens.

12. Fricke and Spilker. *Ber.*, 1925, **58**, 24, 1589. Reduction of thionaphthen to 2 : 3-dihydrothionaphthen and to *o*-ethylthiophenol. Mercuric chloride compounds of thionaphthen and dihydrothionaphthen.

Section D.

Low Temperature Coal Tar Oils.

1. Schütz. *Brennstoff-Chem.* **4**, 84. *J. Soc. Chem. Ind.*, 1923, **42**, 343A. Occurrence of carbon disulphide, methyl mercaptan, dimethyl sulphide and some homologues.

2. Schütz, Buschmann and Wissebach. *Ber.*, 1923, **56**, 1967. Mercaptans in vacuum tar, detected with lead acetate, not identified.

3. *Chem. Met. Eng.*, 1922, **26**, 923. Absence of sulphur in low temperature tar oils.

4. Morgan and Soule. *J. Ind. Eng. Chem.*, 1923, 587, 696. Olefines mask indophenin reaction and thalline test. Suggested presence of hydrothiophens.

Section E.

Lignite Tar Oils.

1. Heusler. *Ber.*, 1892, **25**, 1672; 1895, **28**, 494. Indophenin reaction with fraction of lignite tar oil (b.p. 80—90°) after removal of ketones and olefines with sulphuric acid. Detection of methylethyl ketone.

2. Boes, *J. Apotheker Zeit.*, 1902, **17**, 565. *Central Blatt.*, 1902, II., 804. Occurrence of thionaphthen in lignite tar oil, absence from peat tar and from American crude petroleum.

3. Pfaff and Kreutzer. *Z. angew. Chem.*, 1923, **36**, 437. Presence of ketones (unidentified). Detection of 2-methylthiophen by conversion to corresponding methyl ketone. Indophenin reaction masked by olefines.

4. Ruhemann and Rosenthal. *Z. angew. Chem.*, 1923, **36**, 153. *J. Soc. Chem. Ind.*, 1923, **42**, 344A. Discussion as to presence of thiophen derivatives.

5. Pfaff and Brunck. *Ber.*, 1923, **56**, 2463. Catalytic hydrogenation of a lignite tar oil.

6. Fürth and Jaenicke. *Z. für angew. Chem.*, 1925, **38**, 166—173. Desulphurisation and hydrogenation of lignite tar oils. Oil rich in sulphur and unsaturated hydrocarbons. Cost of purification prohibitive. Thiophen not detected but not necessarily absent.

7. Pfaff and Brunck. Private communication to Fürth and Jaenicke. Thiophen and thioxen in a lignite tar oil.

8. Herzenberg and Ruhemann. *Ber.*, 1925, **58**, 2249. The blue oil of lignite tar oil. Colour of the high boiling fractions 145—170° at 18 mm. probably due to the presence of azulene. Sulphur compounds also present.

9. Vollmer, *J. Soc. Chem. Ind.*, 1925, **44**, 198B. Basic constituents of lignite tar oil,

Section F.

Purely Chemical References to Thiophen and Derivatives.
(See also Victor Meyer under Section C.)

1. Victor Meyer. "Die Thiophen Gruppe," pp. 55, 194, 204. *Ber.*, 1886, **19**, 671. Oxidation of side chains in thiophen homologues. Precautions to be observed. Frequent production of sulphuric acid and complete oxidation. Very important.

2. Biedermann and Jacobson. *Ber.*, 1896, **19**, 2444. Capelle. *Bull Soc. Chim.*, 1908 (4), **2**, 151. Preparation of thiophthen from citric acid and phosphorus sulphide.

3. Autenrieth and Von Brüning. *Ber.*, 1903, **36**, 183. No sulphone but only decomposition products obtained from thiophen and potassium permanganate. See below.

4. Schwalbe. *Ber.*, 1905, **38**, 2206. Precautions to be observed in determination of sulphur in thiophen by the Carius method.

5. Liebermann. *Ber.*, 1893, **26**, 853. Additive compound of thiophen and triphenylmethane.

6. Hofmann and Arnoldi. *Ber.*, 1906, **39**, 342. Insoluble compound of thiophen with ammonia nickel cyanide—$3Ni(CN)_2.3NH_3.C_4H_4S$.

7. Paolini. *Gazzetta*, 1907, **37**, (1), 58. Constitution of mercuric acetate compound of thiophen. Criticism of previous formulæ. Mechanism of reaction. Formation of sulphuric acid.

8. Lanfry. *Comptes rend.*, 1911, **153**, 73, 821; 1912, **154**, 519, 1090; 1912, **155**, 170, 836, 1517. Action of hydrogen peroxide on thiophen and similar compounds giving "sulphones."

9. Steinkopf. *Ann. der chem.*, 1914, **403**, 1–50. Preparation of thiophen and homologues from acetylene and butadienes; mercury chloride derivatives of thiophen and homologues.

10. Hinsberg. *Ber.*, 1915, **48**, 1611. Criticism of Lanfry's results. No thiophen sulphone could be obtained. See F_3.

11. Steinkopf. *Ann. der Chem.*, 1916, **413**, 310, 343. Mercury and arsenic derivatives of thiophen compounds. A new method of preparing thieny ketones.

12. Sernagiotto. *Atti reale Acad. Lincei*, 1919, **28**, (1), 433. Conversion of thiophen to oxalic acid, and sulphuric acid by light in presence of air and moisture.

13. Steinkopf. *Ann. der Chem.*, 1921, **424**, 1–60. Mercuri-chlorides, bromides, iodides and thiocyanates of thiophen homologues and derivatives. Also mercury thienyls. Preparation of thiophen homologues from thienyl ketones. Determination of mercury.

14. Steinkopf. *Ibid.*, 1922, **430**, 41–112. Constitution of thiophen and synthesis of dialkylated thiophens. Critical discussion of behaviour of thiophen homologues to mercuric chloride and of the mercurichlorides towards reagents. Very important. Criticism of Lanfry's thiophen sulphone.

15. Kubota and Yoshikawa. *Jap. Journ. of Chem.*, 1925, **2**, 45. Toxic effect of thiophen on nickel catalyst during hydrogenation of benzene. Thiophen does not affect catalytic activity of copper in reduction of the unsaturated ketone phorone. Further experiments desirable before generalisations should be made.

Section G.

Pyrogenic Syntheses of Thiophen and similar Derivatives.

1. Dziewónski and Rehlander. *Ber.*, 1903, **36**, 965, 1585. Action of sulphur on acenaphthene giving di-peri-naphthylenethiophen.

2. Capello. *Bull. Soc. Chim.* (4), 1908, **3**, 150. Probable formation of thionaphthen from acetylene and sulphur.

3. Oechsner de Coninck. *Bull. Acad. Roy. Belg.*, 1908, 305. Deals with thiophthen.

4. Tschitschibabin. *Centr. Blatt.*, 1916, (I.), 920. Formation of thiophen from hydrogen sulphide, acetylene and a catalyst.

5. Friedmann. *Ber.*, 1916, **49**, 50, 277, 683, 1344, 1352, 1551. Conversion of saturated and unsaturated hydrocarbons to thiophen derivatives by heating with sulphur. Also *Chem. Soc. Abstr.*, 1917, i, 13. Conversion of naphthenes to aromatic hydrocarbons and mercaptans by heating with sulphur under pressure.

6. Meyer and Meyer. *Ber.*, 1917, **50**, 423, 431; 1918, **51**, 1574, 1586. Formation of thionaphthen and thiophthen from acetylene, coal gas or methane and hydrogen sulphide. Absence of thiophthen from coal tar and lignite tar. Non-separable mixed picrate of thionaphthen and thiophthen.

7. *Chemik-Polski* **15**, 10–18. Review of literature dealing with action of sulphur on organic compounds.

8. Steinkopf. *Ann. der Chem.*, 1922, **428**, 123. Action of acetylene on pyrites. Identification of thiophen, 2- and 3-methyl thiophen, 2 : 3-dimethyl-thiophen, 2- and 3-ethylthiophen.

9. Tomkinson. *J. Chem. Soc.*, 1924, **125**, 2264. Production of thiophen and homologues from acetylene hydrogen sulphide and catalysts.

10. Tschitschibabin and Bagdassarjanz. *J. prakt. Chem.*, 1924, (ii), **108**, 200. See G_4 and G_5. Detection of 2- and 3-ethylthiophen.

Section H.

Cyclic Sulphides other than Thiophen Derivatives—purely Chemical References.

1. Meyer. *Ber.*, 1886, **19**, 632. Attempted synthesis of penthiophen.

2. Krekeler. *Ber.*, 1886, **19**, 3266. Synthesis of methylpenthiophen and derivatives. Gives sulphuric acid with 0·3 per cent. potassium permanganate.

3. Lévy. *Chem. News*, 1890, **62**, 216. Alleged preparation of biophen (1 : 4 dithiene) and derivatives. See Victor Meyer, Die Thiophen-Gruppe, 1888, p. 14.

4. Von Braun. *Ber.*, 1910, **43**, 549, 3220. Preparation of tetramethylene sulphide (tetrahydrothiophen), methyltetramethylene sulphide and pentamethylene sulphide.

5. Scheibler. *Ber.*, 1915, **48**, 1825. Suggested occurrence of penthiophen derivatives in shale oils.

6. Grischkewitsch-Trochimovski. *Chem. Soc. Abstr.*, 1917, i., 153–159. Preparation of sulphides with 4, 5 and 6 membered rings and of the corresponding sulphoxides, sulphones, methiodides and mercuri-halides. Rupture of the ring giving open chain derivatives. Bears closely on Mabery's work on "Thiophanes." Direct hydrogenation of thiophen and its methyl and dimethyl derivatives by means of sodium amalgam and alcohol. Yield very poor. Conversion of tetrahydrothiophen to thiophen by passage through a hot tube. Very important.

7. Tscherniac. *J. Chem. Soc.* 1919, **115**, 1085. Preparation of 2 : 5-dimethyldithiene.

8. Meyer and Jacobson. "Lehrbuch der Organischen Chemie," Vol. I., Part II., pp. 107–110, describe and give references to many cyclic disulphides and the corresponding sulphones and methiodides.

9. Steinkopf and Augestad-Jensen. *Ann. der Chem.*, 1922, **428**, 154. Penthiophen derivatives from ethyl diazoacetate and thiophen.

DISCUSSION.

The President thought that the author had demonstrated his results with extreme clearness, and the Institution was greatly indebted to him for the trouble he had taken in making the subject so clear. The importance of research of the kind described in the paper was beyond all question; everyone knew what a nuisance sulphur had been in oil and the difficulty there had been in removing sulphur compounds. Dr. Challenger and his colleagues had laid the foundation for further work by their painstaking research, which would help forward the practical solution of the problem very materially. What applied to Kimmeridge shale oil would apply very largely to other sources of sulphur-bearing oils. Any discussion which took place was, he thought, more likely to be in the direction of suggesting ideas for future research than criticising the methods adopted by Dr. Challenger and his colleagues.

Dr. Dunstan said reference was made in the paper to a possible cause of the production of hydrogen sulphide. Personally, he thought it more likely that the formation of hydrogen sulphide was due to the reaction of free sulphur in the oil itself. Possibly Dr. Challenger could give some information as to the quantity of free sulphur present in the Kimmeridge oils.

With regard to the so-called reaction of acetylene on sulphur, whereby a thiophen derivative was obtained, he would like to know whether there was any evidence at all that the shale oil contained acetylene derivatives. He thought it was just as likely for one of the ordinary disulphides—diethylsulphides, for example—to be oxidised directly by oxygen or by sulphur closing the ring and then for that body to be further oxidised into a "thiophane." He thought Mabery's choice of the word "thiophane" most unfortunate.

Some ten or twelve years ago he had occasion to prepare a number of these cyclic sulphides, and he thoroughly agreed with von Braun as to their utterly intolerable odour. It was very unlikely, however, that bodies of such formulation existed in petroleum.

Mr. J. E. Hackford said there were one or two matters on which he desired to comment.

The acetylene theory did not appeal to him any more than it did to Dr. Dunstan. If sulphur were dissolved at a temperature not exceeding 100° C. in kerosene and kept for some six or eight weeks at that temperature, it would actually go into chemical combination in the form of mercaptans, which decomposed with

the formation of "thiophanes" and the liberation of H_2S, and with regard to Dr. Dunstan's theory of thiophane formation, he found that dialkyl mercaptans could be decomposed by the application of a higher temperature with the elimination of one molecule of sulphuretted hydrogen and the formation of a closed ring.

In the case of shales it had been found—and what was said in the paper rather bore it out—that "thiophanes" or tetrahydrothiophens and such compounds were generally indicative of a decomposed nature of the original compounds present. For example, in a straight oil of the Mexican type he had identified from C_7 to C_{11} compounds, having two –SH groups—i.e., dimercaptans—but whether as straight or forked chains he could not tell. On heating at about 165° C. they decomposed, liberating exactly half of the net weight of sulphur in them, and retaining the other half of sulphur in the form of the so-called "thiophane" ring. Consequently it appeared that the shale oil, having once been distilled at a higher temperature, the original mercaptans had been decomposed and the paper, through these decomposition products, confirmed our knowledge of the composition of the original sulphur compounds that were present in petroleum. The paper gave one or two really good insights into new methods of the isolation of specific compounds in petroleum. He particularly referred to the picric acid being used on the thionaphthen and naphthalene content. Mercuric acetate was used for the removal of thiophens or unsaturated rings, and mercuric chloride for thiophanes or saturated rings. That was good practice and had been used with success in the past.

Mr. E. H. Cunningham Craig wished to ask Dr. Challenger one or two questions. In the first place he would like to know whether as a general rule Dr. Challenger had found there was more sulphur in the higher products—i.e., the larger molecules—than in the more simple ones. The reason he asked that was because the paper dealt with a crude shale-oil as produced, he understood, at Middlewich. A crude oil was a very curious thing. It was wonderful how little either chemists or geologists knew about a crude oil, and a crude shale-oil was perhaps even more difficult to understand than a crude oil; but crude shale-oils from the same material might be entirely different according to the methods by which they had been made. The usual way was to retort by a process which was known as destructive distillation—a very good name for it, because, especially with some of the old vertical retorts, it destroyed most of the valuable oil. He had been making some experiments lately with a new process, the idea of which was not to destroy the oil but to release it from its colloidal com-

bination with as little cracking and destruction of molecules as possible, and it was found that a very highly unsaturated oil came off. He had with him a small bottle of oil obtained from Dorsetshire shale, which he would like Dr. Challenger to examine. The percentage of sulphur was, he believed, something less than 2%. It was not known exactly where the rest of the sulphur had gone. Some of it might still be in the residue of the shale, and some might have been got rid of in other ways. The fact remained, however, that a crude oil had been made from Dorsetshire shale with a sulphur percentage of certainly not more than 2%.

Mr. E. C. Craven said there were one or two chemical points he would like to raise, but he would not elaborate on them. He believed the indophenin reaction was utterly unreliable for the detection of thiophen compounds in any sort of oil; one could prepare a mixture to which thiophen had been added and get no colour at all. He did not know if Dr. Challenger was aware of the essential conditions for that reaction.

He wished to refer to the spirit produced by the hydrogenation of coal. He had been unable to find any thiophen in it, which was strange in view of the fact that coal tar distillates always contained it. The work he had done on that spirit bore out what Dr. Dunstan had said. It contained a very large quantity of elementary free sulphur, and if it were distilled until the temperature in the flask was about 175°, H_2S began to be evolved largely, and sulphur compounds began to distil over, whereas they were not detected beforehand.

Mr. H. G. Shatwell asked Dr. Challenger if he could give some information on the quantitative side of the question, and say what was the lowest fraction in which he had isolated thiophen, and what percentage there was of it in that fraction. In the case of Norfolk shale oil, which differed somewhat from that from Dorset, the fraction at 175° contained about 10% of sulphur. This meant it contained 30% of thiophen, which suggested that if some means could be found for utilising thiophen on a large scale, Norfolk or Dorset shale oils would be a splendid source of that material.

Although the question did not actually bear on the subject of sulphur, he would like to know if Dr. Challenger could say what the percentages of phenols and bases respectively were in the oil.

Dr. Frederick Challenger, in reply, referred in the first place to Dr. Dunstan's remarks, and said that so far as the mechanism of production of the thiophen derivatives was concerned he had already mentioned that he did not wish to commit himself as to the exact methods by which sulphur compounds were pro-

duced in the shale oil. He had only indicated certain similarities which did exist between the production of sulphur compounds at a high temperature, where there was hydrogen sulphide, and the conditions in a simple synthesis from acetylene and sulphur. He would be strongly inclined, however, to defer to Dr. Dunstan in regard to any theories as to the actual mechanism of formation of those compounds in the retort.

Diethyl sulphide was stated on passage through a red hot tube to lose six atoms of hydrogen and give a small amount of thiophen. The Russian chemist Grischkewitsch, whose work was referred to in the paper, also stated that tetrahydrothiophen lost hydrogen and gave thiophen on similar treatment.

He was afraid he could not say anything about acetylene derivatives in the oil at the moment. He was certain that an organic chemist could spend almost a lifetime on investigating the compounds contained in shale oil. Although he was interested in the unsaturated hydrocarbons, up to the present he had not had occasion to deal with them much, because they were removed by the mercuric acetate treatment.

Everyone who had to do with Kimmeridge shale oil agreed that it was very highly unsaturated. He did not know whether the fractions contained acetylenes; they probably contained diolefines because some of the lower fractions tended to deposit a resinous mass similar to that yielded by some specimens of "cracked" oils.

He entirely concurred with what Dr. Dunstan said about the unfortunate use of the term "thiophanes," and indeed had referred to that in the paper. It was unfortunate that Mabery used that term when describing a class of substances of which he had not identified a single member.

As regards Mabery's "thiophanes," in view of the extent to which his work has been quoted, it may be worth while to summarise his results and the conclusions which he actually drew from them.

By dilution of a sulphuric acid sludge from a Canadian petroleum Mabery obtained an oil which was submitted to repeated distillation. The resulting fractions were separately treated with alcoholic mercuric chloride solution, and the viscous precipitates decomposed by hydrogen sulphide to remove mercury. The regenerated oils were separately fractionated and a series of products obtained which, from their b.ps., the sulphur content and the molecular refraction were considered by Mabery to be homogeneous. Whether this was so, or not, was difficult to say, but the treatment with mercuric chloride should have removed most, if not all, of the non-sulphur ingredients. If the mercuric chloride precipitates had been solids instead of (usually) viscid oils, the results would

have appeared more convincing. Each presumably pure fraction of the regenerated oil was oxidised with potassium permanganate to what Mabery considered to be the corresponding pure sulphone. Although some of the analyses showed figures which differed from those theoretically to be expected, some of them appeared to justify his conclusion that he was dealing with pure substances. It appeared doubtful, however, whether this was so in all cases.

Arguing largely from the apparent absence of thiophen derivatives and from the molecular refraction and high density of the different fractions, Mabery concluded that the sulphides he isolated possessed a saturated cyclic structure. It was interesting to quote from Am. Chem. Jour., 1906, 35, 422. "The series contained in the portion of Canadian petroleum with higher boiling points are not alkyl sulphides, mercaptans, thiophens nor ethylene sulphides. Their high specific gravities show that they belong to a new series." He concluded that his products were either "hydrothiophens with long side-chains, (*poly*) methylene sulphides with numerous or long side-chains or simple ring (*poly*) methylene sulphides. . . . The ready formation of sulphones, addition-products with alkyl iodides is unlike the thiophens, but the hydrothiophens may behave differently." (The work of von Braun and of Grischkewitsch-Trochimovski has shown this prophecy to be justified.) "It is improbable that rings with a very large number of carbon atoms can exist. . . . The lowest member of the series separated from Canadian petroleum was $C_6H_{12}S$ b.p. 45–50° at 50 m.m. (or 125–130° at ordinary pressure, p. 408), which may be hexamethylene sulphide or methylpentamethylene sulphide. Higher homologues may reasonably be considered as side-chain derivatives." This product was obviously impure (p. 408,419). Hexamethylene sulphide boils at 169–171° and 2-methylpentamethylene sulphide at 151·4–151·6°. The densities are $d\frac{18}{4}=0{\cdot}9743$ and 0·9449 respectively (Grischkewitsch).

Mabery adds: "The precise form of the ring with reference to the number of carbon atoms it contains is still uncertain; . . . . the central group may be a penta-, hexa- or heptamethylene ring. It has therefore seemed advisable to employ a comprehensive name that shall include any possible arrangement, and the term thiophane has been adopted."

The chief evidence for a cyclic structure for the "thiophanes" was the high density in comparison with the open chain alkyl sulphides. The b.ps. in most cases were not very different from those of the higher alkyl sulphides with the same number of carbon atoms. His sulphones were liquid, but this was true of

many aliphatic sulphones—*e.g.*, *iso*butyl sulphone and ethyl-*iso*amyl sulphone, while di-*iso*amylsulphone melts at 13°.

Mabery observed a difference in the case of oxidation by nitric acid of di-*iso*amylsulphide and his thiophanes (p. 418). He also considered that the violent substituting action of bromine indicated the presence of a new class of compound (p. 415).

It was therefore difficult to decide whether Mabery's "thiophanes" contain open or closed carbon chains, but in view of the work of Thierry and of the present authors his speculations on the properties and possible occurrence of polymethylene sulphides in petroleum were of considerable interest. Mabery's conclusions might well be correct, but they appeared to be based on somewhat insufficient evidence.

With regard to Dr. Dunstan's remarks concerning the occurrence of tetrahydrothiophen and pentamethylene sulphide or their alkyl derivatives in petroleum, it should be mentioned that in a paper published a few weeks ago Thierry demonstrated the presence of the first two compounds in an oil obtained by the dilution of the sulphuric acid sludge of a Persian petroleum.

He had been very interested to hear Mr. Hackford's remarks. In the Bibliography at the end of the paper reference was made to the action of sulphur on saturated, as well as unsaturated, compounds giving thiophen derivatives.

Mr. Hackford referred to the decomposition of sulphur compounds in oils. Personally, he could not say very much about that, not having had occasion to distil the crude oil more than once. It was known that difficulties and ambiguities would be encountered if the oil were distilled at atmospheric pressure, and that was why it was decided to adopt a milder process. The oil had always been distilled with steam, but he had yet to examine the non-volatile fractions. He trusted the treatment with steam was not sufficiently violent to cause any disruption of the molecules of the original sulphur compounds, but he could not say it did not.

He had not yet found any mercaptans in the oil. He believed the phenol fraction might contain a trace of them. It certainly contained sulphur, but he thought very little was present.

Dr. Dunstan had referred to the presence of free sulphur. He had never observed any free sulphur to separate from the oil which had been obtained on distillation with steam—*i.e.*, which made up about 30 per cent. of the crude oil.

Dr. Dunstan, interposing, said he meant in solution.

Dr. Challenger said no indication of it had been observed even when the oil was treated with mercuric acetate.

Mr. Craven had referred to the indophenin reaction, some references to which were made in the Bibliography. It was absolutely useless for detecting thiophen in ordinary shale oil. Unsaturated hydrocarbons were present, and Heusler and others whose names appeared in the Bibliography had shown that in the presence of unsaturated hydrocarbons the indophenin test failed. If one took coal tar benzene and added a little Kimmeridge shale oil, the indophenin reaction could not be obtained, due to the masking effect of the intense red-brown colour produced from the sulphuric acid and the unsaturated hydrocarbons.

It should be borne in mind, however, that pure thiophen and some of its homologues were resinified by sulphuric acid, and that the indophenin test was best applied to dilute solutions of thiophens in saturated or aromatic hydrocarbons. The mercuric chloride or acetate compounds obtained from the oil showed the reaction quite well.

Mr. Shatwell asked about the percentage of bases and phenols. That had not been determined. Practically all the acid and caustic soda washings had been kept, and the percentage was very small. He thought there was some evidence as to the percentage of phenols in Norfolk oil.

In a very early paper by Greville Williams (to which a reference was given in the Bibliography) the bases were examined and it was not thought necessary to go into that again. The bases were free from sulphur.

He had not determined the percentage of thiophen in the different fractions, but as far as he could remember the 109–113° fraction contained about 25% of methylthiophen, judging from the amount of pure methylthiophen obtained at the end.

The sulphur in the higher fractions had not yet been investigated. The highest fractions contained a good deal, and, even if distilled at the best vacuum obtainable, those with a boiling point above about 300° at ordinary pressure began to give off H_2S. He had not determined the total sulphur present, but thought the smaller the molecular weight the higher would be the percentage of sulphur.

He would be interested to examine Mr. Cunningham Craig's specimen of oil.

On the motion of the **President**, a hearty vote of thanks was accorded to Dr. Challenger and his colleagues for their paper, and the proceedings then terminated.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE NINETY-SECOND GENERAL MEETING of the Institution of Petroleum Technologists was held in the Rooms of the Royal Society of Arts, John Street, Adelphi, W.C. 2 on Tuesday evening, March 9th, 1926, Sir Thomas Holland, K.C.S.I., K.C.I.E., F.R.S., (President), occupying the chair.

PROPOSED ALTERATION OF BY-LAWS.

The President asked the SECRETARY to read the following alterations to be proposed by Council :—

PRESENT BY-LAW, SECTION II., Paragraph 1.

" The word petroleum is accepted in the widest sense and includes all natural bitumens (and derivative hydrocarbon products) from the lightest gaseous state as represented by natural-gas, through the varying densities of liquid petroleum, to the various solid forms ; in addition to which is included the legal definition by the Petroleum Act, 1871 (34 and 35 Vict., ch. 105), whereby petroleum is defined in the following words :—' For the purposes of this Act the term " petroleum " includes any rock oil, Rangoon oil, Burmah oil, oil made from petroleum, coal, schist, shale, peat, or other bituminous substance, and any products of petroleum, or any of the above-mentioned oils.' "

Proposed alteration : " The word Petroleum is accepted in the widest sense and includes all natural bitumens and hydrocarbons derived from any source, from the lightest gaseous state, through the varying densities of liquid to the various solid forms."

PRESENT BY-LAW, SECTION III., Paragraph 3.

" 3. Members shall comprise every person who, on the 17th day of June, 1914, was on the register as a Member, and every person thereafter elected or transferred into the class of Members. Every candidate for admission into the class of Members or for transfer into that class shall be not less than twenty-eight years of age, and shall satisfy the Council (*a*) that he has received a good general and scientific education and has been for at least five years in a responsible position with regard to petroleum technology, and is so engaged at the time of his application ; and he shall be, in the opinion of the Council, a fit and proper person to belong to the Institution."

Proposed alteration : To delete the words " and is so engaged at the time of his application."

PRESENT BY-LAW, SECTION III., Paragraph 4.

"Associate Members shall comprise every person who, on the 17th day of June, 1914, was on the register as an Associate Member; and every person thereafter elected or transferred into the class of Associate Members. Every candidate for admission into the class of Associate Members, or for transfer into that class, shall be not less than twenty-three years of age, and shall satisfy the Council that he has received a good general and scientific education, and has had at least two years' practical experience in a position as petroleum technologist, of a character recognised as leading up to qualification for membership, and he shall be so engaged at the time of his application; and he shall be, in the opinion of the Council, a fit and proper person to belong to the Institution."

Proposed alteration: To delete the words, "and he shall be so engaged at the time of his application."

PRESENT BY-LAW, SECTION III., Paragraph 6.

"Associates shall comprise every person who, on the 17th day of June, 1914, was on the register as an Associate and every person thereafter elected into the class of Associates. Every candidate for admission into the class of Associates shall be not less than thirty years of age, and shall be a person who, not being eligible for Membership or Associate Membership, yet by reason of his practical experience in any of the branches of petroleum technology or otherwise, is, in the opinion of the Council, a fit and proper person to belong to the Institution."

Proposed alteration: To delete the words "shall not be less than thirty years of age, and."

PRESENT BY-LAW, SECTION IV., Paragraph 12.

"When four-fifths or more of the votes given shall be in favour of the candidate, such candidate shall be elected; but when a smaller proportion than four-fifths of the votes given shall be in favour of the candidate, he shall not be elected."

Proposed alteration: To alter "four-fifths" in both cases to "nine-tenths."

PRESENT BY-LAW, SECTION IV., Paragraph 13.

"No such ballot is valid unless 11 or more Members or Associate Members ballot."

Proposed alteration: To delete the figure "11" and substitute the figure "50."

PRESENT BY-LAW, SECTION IV., Paragraph 18.

"18. If any Member, Associate Member, Student or Associate shall leave his subscription in arrears for one year and shall fail to

pay such arrears within six calendar months after a written application (according to Form D in the *Appendix*) has been sent to him by the Secretary, his name may be struck off the Register by the Council at any time afterwards, and he shall thereupon cease to have any rights as a Member, Associate Member, Student or Associate, etc."

Proposed alteration : To substitute the words "two years" for "one year," and "three calendar months" for "six calendar months."

PRESENT BY-LAW, SECTION VI., Paragraph 2.

"2. The Entrance Fee for a Member shall be Two Guineas (2*l.* 2s. 0d.) ; for an Associate Member or Associate One Guinea (1*l.* 1s.) ; but each Associate Member, on being transferred to Membership, shall pay an additional Entrance Fee of One Guinea (1*l.* 1s.)."

Proposed alteration : To insert the words "or Associate" after the words "but each Associate Member."

PRESENT BY-LAW, SECTION VIII., Paragraph 2.

"The Honorary Secretary shall be *ex officio* a Member of Council, and responsible to the Council for the General Administration of the Affairs of the Institution."

Proposed alteration : To insert the words "and of all Committees" after the words "a Member of Council."

PRESENT BY-LAW, FORM D.

"Dear Sir, I am directed by the Council of THE INSTITUTION OF PETROLEUM TECHNOLOGISTS to draw your attention to Clause 8, Section VI., of the By-laws, and to remind you that the sum of £ . . . . . of your annual subscription to the funds of the Institution remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid within six calendar months from this date, otherwise the Council will be under the necessity of exercising their discretion, as to using the power vested in them by Clause 18, Section IV., of the By-laws."

Proposed alteration : To substitute the word "three" for "six" calendar months.

The President formally gave notice that the alterations which had been read by the Secretary would be proposed at the Annual Meeting.

The President said Dr. Arthur Wade had spent twelve years studying the reported and supposed occurrences of oil in Australia, and many of his papers, both geological and palæontological, had been published there as official reports. The paper gave a summary

of his investigations, especially from the point of view of the prospect of obtaining oil; the paper was thus of unusual value, because of the thoroughness with which the subject had been dealt with, and it was placed before the members soon after the author had finished his recent work in Australia.

The following paper was then read :—

The Search for Oil in Australia.

By Arthur Wade, D.Sc., A.R.C.S., F.G.S., M.Inst.M.M., F.Am.G.S. (Member).

1. *Brief History of the Search to* 1913.

In no part of the world have governments and peoples been more anxious to obtain supplies of petroleum during the past twenty-five years than in Australia. The whole population has been fully aware of the necessity for, and the advantages of, internal or near sources of supply. Fairly abundant supplies of coal are distributed around the margins of the Continent; fortunately, in most cases, within easy access of the centres of population and the seaboard. But the development of the motor vehicle, the aeroplane and the oil-burning vessel, for war or trading purposes, on the waterways of the world has developed a situation with regard to liquid fuels which Australia has not been able to meet from within. A Continent of vast distances and widely separated groups of settlement, the motor vehicle has become an absolutely necessary means of communication, and of opening up the country. In fact, for such vehicles Australia constitutes one of the best markets in the world. Lines of aerial communication are developing rapidly, and for the carriage of mails by this method Australia stands second to none. Furthermore, the white community of Australia is the most isolated in the world, vast distances of sea have to be covered before the Australian can come into touch with any civilisation comparable to his own, and this isolation fills his mind with a certain amount of anxiety as to the safety of his position, leads to some antagonism towards the coloured races who are his nearest neighbours and from whom he suspects some challenge may come in future years, and has led to the policy of a white Australia. Therefore in addition to the special necessity which exists in Australia for supplies of liquid fuel for industrial purposes and means of communication, there is also to be faced the more urgent necessity which arises from the need to ensure the safety of the Commonwealth in view of its unique geographical situation. Until recently, about 80 per cent. of petroleum products used in Australia were imported from America, which necessitates

carriage over 6,000 miles of ocean. The rest came from the Dutch East Indies, not so distant but still entailing a sea voyage sufficiently long to be hazardous in time of war. To-day, the Anglo-Persian Company in partnership with the Commonwealth Government, is obtaining an increasing share of the business, but the oil has to be imported from the Persian Gulf, which makes the general position no better, and the urgency of obtaining supplies, if possible either within the Commonwealth or close at hand, still exists.

Stimulated by the success achieved by the Scottish Oil Shale Distillers a generation or so ago, attention was first paid to similar deposits which were known to exist, especially those in New South Wales, and which proved to be extraordinary in their quality and richness. But although at first a successful career of development appeared to be certain, increasing competition from without and labour troubles within, together with incumbrances due to what are now generally regarded as errors in policy and management in the early stages, have caused the business to languish until at the moment it seems almost to have succumbed. There is, however, hope that the industry will be given a new lease of life. Interest has been revived, stimulated by new driving forces and new methods.

The public was disappointed at the comparative lack of success which had attended the attempts made to obtain supplies of liquid fuel internally from the rich kerosene shales and similar deposits. The wonderful strides made by the drillers of oil wells in America were watched with somewhat jealous eyes, and the question arose as to whether a Continent of the size of Australia could possibly exist without containing pools of petroleum similar to those which were being tapped almost daily in the U.S.A. to the great advantage of that country. A few small syndicates and companies were formed and some search for oil was commenced. Owing to two interesting factors the coastal regions of South Australia were most highly favoured for prospecting. Along the southern coasts of the Continent, from Southern Tasmania to the Leeuwin, fragments of bitumen, sometimes weighing upwards of 1 cwt., have been discovered from time to time. There is evidence that finds of this nature have been made throughout the greater part of the last century. It is found in small, rounded black pieces, larger and more angular fragments, brittle, fissured and much oxidised and otherwise affected by exposure to air and sun, and more rarely, in large cakes three or four inches in thickness, which are sometimes of a deep brown colour varying greatly in plasticity and in the degree of oxidation and look remarkably fresh in origin. The greater number of these finds have been made on the coasts of South Australia between the borders of Victoria and Western Australia, although a considerable number of finds have been made more

recently on the Southern coasts of Western Australia and of Victoria, especially at points near to the South Australian borders.

The fact that some of these fragments after exposure have a specific gravity greater than that of sea-water led some observers to the conclusion that they originated from seepages near to the shore line, and some drilling was done near places where fragments of bitumen had been discovered. The results were entirely negative, and prospectors went inland hoping to discover outcrops which would confirm their theories as to the origin of the bitumen. This search again failed but a different substance was found, chiefly in depressions in that part of South Australia known as the Coorong.

This area has some peculiar physical features. An area of some thousands of square miles having a fair though erratic average rainfall it has no natural drainage system. Several ranges of hills run parallel to the coast line. These ridges are old sand dunes now in a more or less consolidated condition. In rainy seasons the ridges bar the drainage of water to the coast and the depressions between them become swamps or in some cases temporary lakes from which the water slowly percolates or is lost by evaporation. The Government of South Australia has now cut artificial drainage channels through some of the ridges and so greatly improved the country for settlement. Around these old swamp depressions the curious elastic substance known as Coorongite is found sometimes in fair, though never in very large quantities. It is a brown leathery material usually found in flakes of from ¼ to ½ inch in thickness, and often mingled with pieces of dried marsh grasses and seeds which often form a mat-like texture. It is certainly of recent formation from the organic matter in the swamps. From our point of view its chief interest consists in the fact that from it can be obtained by distillation, in any ordinary retort, a dark brown liquid which resembles a crude petroleum and has a paraffin base. In some parts of the Coorong the farmers call this substance "petroleum," and a discovery of it is reported as a "find of petroleum," or a "petroleum seepage."

Some prospectors have gone so far as to connect the occurrence of bitumen on the coasts with those of Coorongite inland, and boreholes were sunk in several localities upon such evidence with very unsatisfactory results.

2. *The Search in Papua.*

This stage of development was reached about the years 1912-13. In the year 1912, a discovery was made which caused some excitement and aroused new hopes just at a time when there was some current feeling of disappointment with the results obtained so far from the efforts made to discover possible sources

of supplies of liquid Petroleum in Australia. More or less accidentally, true seepages of oil and gas were found near the banks of the Vailala River at the head of the Gulf of Papua. Claims were pegged out and a great deal of activity ensued which was subsequently checked by the decision of the Commonwealth Government that the development of possible oilfields in Papua would be reserved as a monopoly by that Government. Drilling was commenced by means of hand-boring plant and a good showing of light oil was encountered at a depth of about 200 feet, but the country was unexplored and unexamined and the geological features unknown. Rapid reconnaissance expeditions were undertaken by Carne*, the well-known N.S.W. geologist, and afterwards the late Evan Stanley,† who had just been appointed to the post of Government Geologist for Papua. Carne's expedition was primarily for the discovery of possible coalfields but he also visited the newly discovered Vailala area, as well as areas which were being developed for copper.

In 1913 I was invited by the Commonwealth Government to make more detailed investigations and to make suggestions for the future development of the oil bearing territory, and parts of the years 1913 and 14 were spent on this work.‡ Numerous seepages of petroleum and emissions of natural gas were discovered at various places between Yule Island and the Purari Delta in highly folded late Tertiary deposits chiefly of Miocene and Pliocene ages. The folding appears to increase in intensity as the strata are traced westwards from Yule Island, and inland towards the high mountain ranges which form the axis of New Guinea. A thick series of blue clays with subordinate beds of sand, calcareous grits, thin impure limestones and some thin seams of coal constitute the important group of strata in which evidences of the presence of oil are met with. These deposits were laid down in a huge tropical delta surrounded by dense jungle. A good deal of drilling was accomplished under my control from 1915 to 1919, and later under the control of the Anglo-Persian Company. A few thousand gallons of light oil of excellent quality were obtained from shallow depths under my régime though larger supplies were hoped for at depth. No boring has so far been carried to sufficient depth to adequately test these deposits. Conditions are trying and difficult even now, but these natural difficulties were much greater in the

* J. E. Carne, "Notes on the Occurrence of Coal, Petroleum and Copper in Papua." Dept. of External Affairs: *Melb. Bull. No.* 1, 1913.

† E. R. Stanley, "The Papuan Petroleum Area." *Rept. Australian Ass. for the Adv. of Sci., Melb.*, 1913, XIV., Sec. C, pp. 200-6.

‡ "Petroleum in Papua." A. Wade.—*Commonwealth Parl. Paper, Melb.*, 1914.

pioneering stages and were greatly accentuated by the war. The Government has recently abandoned its monopoly and the work which is now in the hands of private companies has spread to what was hitherto German New Guinea, where surface evidences are of equal importance to those in Papua. All that can be said of this region at present is that no oilfield has yet been developed, but it is to be hoped that the more widely spread activity which exists at present will result in the discovery of more than one pool of importance both to commerce and the natural resources of the Empire.

3. *The Search for Oil in Australia since* 1913.

(*a*) *General Remarks.*—Meanwhile the search for oil in Australia itself was being extended widely and practically the whole of the marginal areas of the Continent had come under the eye of the prospector, trained or untrained. But the various State geological surveys were also alive to the importance of this problem and in many instances special examinations and reports were officially made in connection with regions which possessed geological features which warranted such work. On the other hand, owing to pressure exerted frequently by unofficial prospectors, State geologists were often asked to report on areas which were quite hopeless as potential sources of supplies of petroleum.

The chief source of trouble in connection with the search for oil in Australia in the early days was the general lack of knowledge concerning oilfields, the conditions under which oil accumulates and the methods by means of which development and production are obtained and maintained which unavoidably exists in a thinly populated country so isolated from the rest of the world as is Australia. I venture to say that we in Great Britain have suffered, to a lesser degree perhaps, from similar causes, especially at the directing and financial end of the business. Resulting from such circumstances the prospectors have not infrequently been old and untrained mining prospectors with some practical and hard won knowledge of the modes of occurrence of such minerals as gold but none whatever of petroleum. Even when the qualified geologist and mining man has been employed on the work, lack of special training and experience with regard to oil has sometimes proved a severe handicap both to the prospector himself and to his employers. I must say, however, that there has been a distinct improvement in this direction since 1913 and the methods employed to-day are in some cases quite sound and scientific. These facts have been recognised by some of the concerns which have interested themselves in the finding of oil and there has been a tendency of late to bring in American oil geologists in consequence, but it

should be evident from what I have said that this step would have been much more profitable in the early days of prospecting for there are to-day Australian geologists who are sufficiently well acquainted with the principles of oil occurrence to be able to carry on the work. The better type of oil geologist from the American fields has, however, some lessons to teach and I think, therefore, that these visits will be of value.

The best way of dealing with the search for oil in Australia since the outbreak of war will be to give a brief account of my own researches. While advising the Commonwealth Government on matters connected with the development of possible oilfield areas, especially in Papua, between the years 1913 and 1920, I was called upon at times to examine areas in Australia which local prospectors considered to be favourable or in which money was being spent on drilling by locally formed companies. The most serious piece of work of this nature was undertaken in South Australia at the request of the South Australian Government in 1914 and 15. Later, in the year 1924, I was again invited by the Commonwealth Government to examine the northern part of Western Australia and the Northern Territory. Subsequently, various requests for my services resulted in the Commonwealth Government asking me to extend my investigations to Queensland, New South Wales, Victoria, South Australia and the southern part of Western Australia, so that during the ensuing two years I covered the greater part of the Continent. Reports were submitted to the Government as the work proceeded and have been published chiefly as Parliamentary Papers.*

(*b*) *South Australia.*—At the time of my first visit to South Australia in 1914, prospecting was in the stage where it depended almost entirely upon the bitumen washed up on the shores and on the discoveries of Coorongite in the South-Eastern part of the State. Prospectors were interested chiefly in a broad littoral belt on the southern margins of the State, and were mostly occupied with Eyre's Peninsula, Kangaroo Island and the South-East. A little drilling had been accomplished in places, mostly by means of light plant, though heavier plant was being obtained in the South-East. I came to the conclusion that the greater part of this belt north and north-west of Kingston, consisted of a cover of Tertiary sediments overlying a very irregular surface which consisted of gneisses and granites on the one hand, and more or less altered Palæozoic and even older sediments, including an ancient

* A list of these reports is given on page 31. Reference should be made to these for many references and much detail which have necessarily been omitted from this paper for the sake of brevity.

metamorphic series on the other hand. For the most part, the Tertiary cover is thin and the granitic and old sedimentary rocks poke through it in very many places, sometimes outcropping over pretty extensive areas or showing themselves under the thin Tertiary capping in the coastal cliffs. Local basins in the buried landscape might locally give greater thicknesses to the Tertiary sediments and in some of these lenses of impure lignites occur. But although the nature of the country gives ample scope for the occurrence of seepages of petroleum, should petroleum be anywhere present, no such seepage has ever come to my notice. Pseudo-seepages of the usual hydrated iron oxide variety carried me on many a wild-goose chase and many a dark-coloured or evil-smelling substance was submitted to me as evidence of the presence of petroleum. Structure and even geological detail were almost entirely disregarded. All that existed was a cheerful optimism based on hope and faith and on little else. The whole of the littoral of South Australia, from Kingston to the borders of Western Australia, is in my opinion hopeless country in which to seek for commercial supplies of petroleum.

South and south-east of Kingston there exists a large area of Tertiary sediments which extend eastward into the adjoining State of Victoria. They appear to range upwards from the Eocene, but owing to the fact that the Palæontology has not yet been sufficiently studied, it is impossible to divide the series satisfactorily into stages or zones which would correlate the sequence with better-known areas in Europe. On the South Australian side, granites and metamorphic rocks appear around the margins of the area. On the Victorian side sedimentary rocks ranging from Upper Carboniferous (?) to Jurassic appear. The Tertiary deposits fill a large basin-like depression in these older rocks and in the centre of the basin they attain a thickness which is unknown, but which must be measured in thousands of feet. Except for one very doubtful seepage in the gorge of the Glenelg River on the Victorian border, where the best exposures of the Tertiary strata are to be seen, no oil-bearing stratum has been observed. I examined the place in the bed of the Glenelg River where the seepage is supposed to occur, but apart from a deposit of black organic river mud resting on massive limestones, I could discover no evidence of an oil seepage. If a seepage does occur here, it is accompanied by none of the phenomena which usually accompany an escape of crude oil. The black river muds may contain minute traces of oil, but that is another story. The section in the Glenelg Gorge does show that the beds have been subjected to movements which have caused folding. Elsewhere the observable dips are very small as a rule. When some horizon is traced for considerable distances folding on

a large scale seems to be indicated, but in the absence of detailed Palæontological work and mapping, the observer cannot always be sure that the horizon he picks up after a break is the same as the one he has been following. It is a case in which much work is required, detailed Palæontological work, together with detailed mapping, levelling and contouring, before it can be proved that suitably closed structures exist in this area. In the 1914-15 period serious work with efficient plant commenced near the S. Australian margin of this Tertiary basin, and a bore was put down to a depth of over 4,000 feet near Robe. It bottomed on Palæozoic or older rocks, and yielded nothing of importance. Since that period the work of prospecting in South Australia has gradually come to be concentrated in this area and a number of companies have been and are drilling on sites which are thought to be suitable from a geological point of view. Under the surface limestones considerable thicknesses of light and dark-coloured clays sometimes containing impure lignitic seams have been proved with some bed of sandstone interspersed but nothing like an oil sand has been recorded. Hopes are often based on the fact that from some of the drilling samples very minute quantities, of the nature of ·005 per cent., of oily matter resembling mineral oil can be extracted by solvents. There is a remarkable similarity, both quantitatively and qualitatively, between the results of such extractions from bore samples from all over Australia, from Western Australia to Queensland, and very many analyses of samples from widely-separated districts give results similar to the above. What is the significance of such phenomena? Personally, I believe that such results are unimportant. Moreover, I am inclined to think that the degree of metamorphism which has taken place in the carbonaceous matter contained in these deposits has not been sufficient to produce any considerable body of petroleum. Beneath these beds near the border, however, Jurassic and Permo-Carboniferous sediments are likely to occur, and there are some grounds for hoping that oil may have been formed in these formations. A suitably-located deep boring may therefore solve many problems and save money in the long run.

Another interesting basin occurs inland, at the far north-east corner of the State. It is part of the great artesian basin which occupies parts of South Australia, Queensland and New South Wales, and is constituted by rocks of Mesozoic age, but this basin must be dealt with under the heading of Queensland, wherein the greater part is situated.

(c) *Western Australia.*—During the past few years, the great Permo-Carboniferous basin which exists in the Kimberley region

of Western Australia and is drained by the Fitzroy River, has been of much interest to those who seek for possible sources of petroleum in Australia. The northern part of the Kimberleys consists of great plateaux and ridges of metamorphosed sediments mostly Pre-Cambrian in age, containing large areas of granites and gneisses, the southern margin of which sweeps round in a great curve from Yampi Sound on the 16th parallel of latitude to Christmas Creek, on the 20th parallel and back again to the 16th parallel, where it crosses the border into the Northern Territory. To the south these rocks are thrown down by a series of great step faults and form a depression which is occupied by Permo-Carboniferous strata. Similar types of metamorphic rocks crop out on the southern edges of this basin about the 23rd parallel. The eastern margins are not well known for the country is still largely unexplored. To the north the Permo-Carboniferous sediments are folded into long wrinkles which run parallel to the edges of the basin. The Permo-Carboniferous series consists chiefly of flags, sandstones and some carbonaceous shales with thin fossiliferous limestone horizons above; massive sandstones and conglomerates, glacial till and blue and grey shales resting on a series of thick limestones beneath. These beds are at least 4,000 ft. in thickness.

The first evidences of petroleum were found in a shallow boring for water in the massive limestone of the Rough Range at Price's Creek on the northern margin of the basin. Subsequent bores gave small showings and strong smells of petroleum in calcareous shales and massive limestones down to 700 ft., but nothing of commercial importance. Operations were then transferred to Mount Wynne, where better structural conditions had been mapped. A bore was sunk to a depth of about 2,000 ft. through massive sandstones and occasional bands of shale and yielded several slight showings of oil, usually, however, in the form of asphaltum or bitumen which occurs either as an infilling in fissures or as small blebs in the sandstones. Mount Wynne is about 90 miles from Price's Creek, and it is now thought that the chances of success may be greater in the Pool Range, which is both nearer to the bituminous limestones of the Rough Range and to the margins of the basin. The structure is that of an elongated dome, the axis of which is broken by trough faulting.

I am of opinion that Cambrian or Pre-Cambrian sediments and metamorphic rocks underlie the Permo-Carboniferous strata, and that the chances of obtaining oil are confined to the Permo-Carboniferous. The nature of the strata as a possible source of commercial supplies of petroleum is not very promising, but small amounts of oil certainly do exist in these beds, and the geological structures which are present on the margins of a great synclinal depression

are quite favourable. The country is certainly worth testing by means of a bore situated on structure and deep enough to test the lower members of the Permo-Carboniferous.

E. T. Hardman's Report on the Geology of the Kimberley District published in 1885 has long been a standard work of reference. Hardman shows on his maps a second but smaller basin of Permo-Carboniferous rocks to the north-east of the Fitzroy area and on the Ord River, and since seepages of bitumen were reported in that locality it was thought that conditions might be very similar to those of the Fitzroy basin. It was found, however, when I visited this area on the Ord River, that the differences were very marked indeed. Instead of finding a basin of Permo-Carboniferous rock, I found fossiliferous strata of Middle and Lower Cambrian age crowded in places with an Olenellus type of fauna. The structure is of intense geological interest. The area is 80 miles long by 40 miles wide, situated on the borders of Western Australia and the Northern Territory. It is an oval tract of little altered Middle and Lower Cambrian sediments, chiefly consisting of limestones, shales and mudstones, sometimes carbonaceous, with very few porous or sandy horizons. In the centre of the basin the beds are almost horizontal or slightly folded as a rule, but all round the margins the beds turn up abruptly, the dip often approaching the vertical. A massive limestone forms the lower member of the series, and the abrupt dip has caused it to form walls which run for miles around the margins of the area. Below the limestone beds of basalt, over 3,000 ft. in thickness, are present and are folded in the same way as the overlying limestones. The basalt forms a belt which completely surrounds as well as underlies the Cambrian sediments and the wall-like structure of the limestone is due to the fact that the basalt has weathered more rapidly than the overlying strata. The basalt on the margins soon turns over and lies almost horizontally again with outliers of the basal limestone resting conformably above showing a perfect monoclinal structure. Below the basalt is another series of more altered sediments, consisting of quartzites, flags, shales and two massive siliceous limestones which are quite devoid of fossils. This series is at least 12,000 ft. in thickness, and is most likely Pre-Cambrian in age. I found that it covered great areas in Northern Australia from Yampi Sound to the Gulf of Carpentaria. Some of the flaggy beds yield a number of obscure fossils, the determination of which must be left to future workers who have here a great field for research. The whole series is indeed of great interest, both from geological and palæontological points of view. In the north-west part of the basin near the junction of the Negri with the Ord, the monoclinal dips were the lowest observed. Brine springs occur in the bed of the Ord River and large pseudo-

morphs after salt crystals were found in Cambrian mudstones. Most remarkable of all, the upper part of the underlying basalt was found to be impregnated with bitumen in places. The bitumen fills fissures and vesicles in the basalt and softens and runs out in the heat of the sun. Microscopic examination has led to the conclusion that the bitumen is an infilling which reached the basalt long after cooling and is not likely to have been caught up from neighbouring sediments during flow. The Okes-Durack Test Bore was situated on a low fold near the centre of the basin. It passed into basalt at a depth of 788 ft. Blue and gray shales and mudstones containing gypsum, with bands of limestone predominated. A little gas with a smell of petroleum and sulphur, were noted in the lowest limestones just above the basalt, but no horizon from which petroleum could be expected was found. Now petroleum could very well have originated in such beds, and I think that we have here a case of an extinct oilfield, an area which was formerly oil-bearing perhaps in commercial quantities, but time, crustal movements, the percolation of water, denudation and other causes have removed all but the last traces of petroleum which in the last and most stable form of bitumen is retained in the only suitable porous body, the vesicular upper surface of the underlying basalts.

Before passing from Western Australia to the next area, I will deal briefly with the southern part of the State, which I examined at a subsequent date. From the borders of South Australia to Cape Leeuwin the underlying rock consists chiefly of granite and old and more or less metamorphosed sedimentary series. In places these rocks are thinly covered with sands and travertinous limestones of recent origin. In depressions, beds of carbonaceous mud and even lignites have accumulated. These have given rise to some hope that oil could be obtained by boring into these beds. The fact that minute traces of oily matter can be extracted from such muds by means of solvents and more by distillation methods has supported such hopes but really there is little chance that an oilfield will ever be developed in this part of Western Australia.

(*d*) *The Northern Territory.*—Geologically the Northern part of the Northern Territory and the Kimberley region of Western Australia are one area. Metamorphic rocks and granites overlain by an ancient sedimentary series probably of Pre-Cambrian origin, some tracts of proved Cambrian age and large areas of basalt occupy by far the greater part of the area as they do in the Kimberleys. There is great geological similarity over the whole region. Copper, gold and tin are more certain of providing the prospector with adequate returns for his work than is petroleum.

Two occurrences of bitumen are, however, worthy of note, and both are remarkable in their nature. The more important is to be found on Elcho Island to the north-west of the Gulf of Carpentaria. Here indurated Pre-Cambrian flags, shales and quartzites outcrop. They are almost horizontal or dip at very low angles. In the shaley layers between quartzitic bands are found isolated flat cakes of very hard bitumen about 1 inch in thickness, and sometimes about 1 foot in diameter. They are distributed almost in the same manner as are concretionary nodules in shale beds. I do not regard the occurrence as of any importance commercially, but it is extremely interesting to find bitumen in beds which show marked signs of metamorphism and of such ancient origin. I look upon these cakes as the final remnant of what must have been a more important accumulation of bitumen, and we may have here the last stages of an even older accumulation of oil than that which may have existed in the Ord River basin. The second occurrence is closely allied. Near the Roper River at the Waggon Lagoon between 300 and 400 miles inland from Port Darwin, I found bitumen again in a vesicular basalt, but in this case the basalt was impregnated at its junction with quartzites, shales and flags similar to those of Elcho Island. Again, the occurrence is more of geological than of commercial interest, and no development is likely to follow upon such a discovery.

(*e*) *Queensland.*—Since 1897, when a large volume of natural gas was encountered in a boring for water at Roma, in Queensland, this part of Australia has been considered by those who have studied the Australian problem to be of greater promise than usual, so far as oilfield development is concerned.

Roma is situated near the rim of the great artesian basin which occupies a large part of Western Queensland as well as parts of the Northern Territory, South Australia, and New South Wales.

The important groups of strata forming this basin are the Triassic (Ipswich), consisting chiefly of clays, sandstones and important coal seams; the Trias-Jura or Jurassic, divided into two groups, the lower being the Bundamba Sandstones, a very massive group of sandstones with some thin carbonaceous shales in places and the Upper or Walloon Coal Measures, consisting chiefly of more flaggy sandstones, calcareous and carbonaceous shales with concretionary iron stone bands and some coal seams, and of less importance to us overlying Cretaceous and Tertiary deposits.

Important water supplies are obtained in the centre of the basin, sometimes from depths of over 7,000 ft., from the porous sandstones of the Trias-Jura. The natural gas at Roma is also from the Walloon Measures. Moreover, some actual crude oil associated

with hot mineralised water has been observed flowing from deep artesian bores in this formation in the neighbourhood of Longreach in central Queensland. This crude oil becomes a dark brown natural wax at normal temperatures, 97 per cent. of which is soluble in petrol ether.

The strata constituting the Trias-Jura system were entirely laid down under fresh water conditions. They are extremely false bedded, lenticular and erratic, so that it is almost impossible to trace any bed very far in any direction, and equally impossible to correlate the logs of borings, even when the bores are only short distances apart. Ordinary reconnaissance field work reveals little apparent folding. The beds commonly appear to be almost horizontal, but actually they dip to the south and south-west towards the centre of the basin at a rate which averages about 40 ft. to the mile. It is difficult country to work in, large areas are covered with an almost impenetrable scrub of prickly pear and settlement is very sparse. It is evident that if structural features are to be found, a good deal of patient detailed work on modern lines will be necessary. Jensen and Ball, working on the Queensland Geological Survey have perhaps done more careful geological work in this region than any others, and both claim that dome-like structures exist on the margin of the artesian basin, but there is a total absence of the detailed work in this area which is very necessary in such conditions.

The No. 3 bore at Roma gave a yield of wet natural gas which was estimated by the Government analyst to be 10 million cub. ft. a day. He was able to extract one and one-third pints of gasolene per 1,000 cub. ft. of gas. The analysis showed 82·4 per cent. of the Paraffin Series, including ethane, and 5 per cent. of Benzenes to be present. The carbon-ratio obtained from analyses of coals from the strata show a very satisfactory state of metamorphism for the formation and occurrence of oil, but there is one peculiar and disquieting circumstance. The waters from the various deep bores in this part of Queensland are always hot. At Ruthven I found the temperature of the bore water coming from a depth of 4,100 ft. to be over 190° Fah., the temperature gradient averages close to 1° Fah. for every 30 ft., which is a much more rapid rise of temperature than is normal. It has been suggested that the high temperatures which exist at depth in this region may have caused any petroleum which may have formed to dissociate, the higher fractions being driven off as gases leaving only heavy residues behind. This would explain exactly what is being found—heavy waxy residues in the bores around Longreach and the accumulations of light gases in favourable localities such as Roma. Natural gas wells giving such quantities as were obtained at Roma should,

however, be of great value to Central Queensland, and the possibility of obtaining such supplies cannot be overlooked. The work of prospecting and drilling will certainly be carried much further in Queensland. All the bores at Roma had unfortunate histories and endings, but the only result of these has been to make the Queensland concerns more careful with regard to both drilling equipment and personnel.

Some drilling for oil has been accomplished in other parts of Queensland during recent years, but none of the areas are likely to become important. Minute showings of oil from sludges, drill samples and waters have been recorded but although some carbonaceous deposits seem frequently to yield traces of oily matter which resembles mineral oil when treated with solvents, many of the showings reported are undoubtedly due to drainage into the borehole from the surface operations or from lubricants used on tool joints, casing or even the dressing of wire lines. An experiment with the mud being circulated through a rotary boring at Orallo, North of Roma, showed that almost exactly the same percentage of mineral oil could be extracted from it as the average extraction obtained by solvents from bore samples and sludges from other bores widely distributed, not only in Queensland, but in the rest of Australia. In the first case, there was no doubt whatever that the oily matter contaminating the mud arose from the working plant above, so that the result was of very great significance.

(*f*) *New South Wales.*—No authenticated seepages of oil or gas nor occurrence of bitumen originated the search for petroleum in this State, rather has it been inspired by the presence of well-defined and suitable structural conditions in strata containing an abundance of coal and otherwise favourable for the formation, accumulation and preservation of supplies of petroleum. Such structures have been found in the north-west part of the Newcastle-Maitland coalfield area on the margins of another great Permo-Carboniferous basin in which Sydney is centrally placed. This may be called the Sydney Coal Basin. Most of the exploratory work of importance accomplished during the past few years has been by an American geologist, Mr. H. C. Millard, with Professor Sir Edgeworth David's classical work on the Geology of the Hunter River Coal Measures as a basis. In this case the carbon-ratio hypothesis has been the chief guiding factor, so it may be well to discuss this hypothesis briefly for the benefit of those who may not yet have studied it.

Numerous investigations in American oilfields have established the fact that the degree of metamorphism undergone by coal seams gives some measure of the chances of obtaining oil and natural gas in the associated strata. That is to say, there is a

stage in the changes undergone by coal seams which corresponds with the natural conditions under which carbonaceous matter becomes petroleum. The percentage of fixed carbon in a pure coal is taken as the measure of metamorphism. The analysis of an ordinary coal is usually given under the headings of moisture, volatile matter, fixed carbon and ash. From these we eliminate ash and moisture and the percentage ratio of fixed carbon to the volatile matter is the basis for our hypothesis. Fuller gives the relative chances of finding oil corresponding to the ratios obtained by this method as follows :—

Zone of 50 to 55 carbon ratios	100
„ „ 55 to 60 „ „	10
„ „ 60 to 65 „ „	probably less than 1

Now this is a very important theory if it can be proved to be of universal application. In connection with American oilfields remarkably accurate results have been obtained from it. Such an hypothesis must be applied with caution and must be considered in conjunction with all other important factors which must be studied in connection with any prospective oilfield area.

Curves drawn through places where similar carbon-ratios are obtained from analyses of coals are called "isovolves" or "isocarbs." Mr. Millard worked out a large number of carbon-ratios from analyses of coals in the Sydney-Newcastle-Maitland coalfield area and was able to draw an isovolve map. The isovolve for a carbon-ratio of 50 was drawn around the colliery town of Branxton on a dome-like structure known as the Lochinvar dome. A 55 isovolve coincided roughly with the outcrop of the lower or Greta Coal Measures, approximately just outside the Lochinvar Dome area. The 60 and 65 isovolves ran through the middle and upper coal measures in the Newcastle coalfield area, while the 70 and 75 isovolves crossed the deeper parts of the Basin in the neighbourhood of Sydney.

If, then, the hypothesis holds good with regard to this coalfield area, it would appear that the chances of obtaining supplies of oil from the dome-like structures to the north-west of the area which fortunately occur in the regions showing isovolves ranging between 50 and 60 should be remarkably good. In order to be sure of the facts I worked out the carbon-ratio figures again including this time new data supplied by the Geological Survey Department in Sydney. I discovered first that it was very doubtful whether an isovolve of 60 could be drawn through the Newcastle coalfield area at all. I found that where a carbon-ratio of 60 or under resulted from analyses of coals in the upper and middle coal measures other analyses, often from the same mine, and sometimes

from a neighbouring mine working the same seam, would give ratios well in excess of 60, and the average of results obtained in any area always exceeds 60.

The 50 and 55 isovolves were based entirely on results obtained from the Greta coals. Now these coals lie at a depth of over 7,000 ft. below the base of the middle and upper coal measures in which the carbon-ratio exceeds 60. This is a difficulty, for if the carbon-ratio represents the degree of metamorphism which has taken place in the strata, we should expect to find higher ratios in these lower coal measures than in the upper ones. Still assuming that the carbon-ratio theory was in general correct, I came to the conclusion that there must be some peculiar factor which was specially affecting the lower or Greta coals. It occurred to me that the carbon-ratio theorists had probably been dealing with coals of pretty uniform types of origin, and that there may be other types of coal which did not conform to the theory. I therefore studied the Greta coals in the field with this in mind. I found that they were closely associated with bands of cannel coal and kerosene shale and that seams of bituminous coal contained patches where such coal passed gradually into kerosene shale. In Queensland I had found that impure coals gave much lower carbon-ratios than purer coals in the same area. I therefore formed the opinion that the cannels and kerosene shales associated with the Greta coals caused the carbon-ratio to be apparently much lower than it should be and that the true stage of metamorphism, was not represented by ratios of 50 to 55 but by a figure which would and should be higher than the carbon-ratios obtained from coals in the middle and upper coal measures of neighbouring districts. I also asked Prof. Sir Edgeworth David, who has special knowledge of this area, whether there were microscopic differences between the Greta coals and those of the overlying measures. He replied that the Greta coals all carry Reinschia australis, the body which when concentrated forms kerosene shale and that the upper coals do not contain this fossil to any appreciable extent. It was thus very plain to me that the presence of seams of cannel or kerosene shale in coals distinctly vitiated results obtained from the working out of carbon-ratios. I was confirmed in this opinion subsequently by a paper by Mr. William L. Russell in *Economic Geology* of May, 1925. He finds that the carbon-ratios of cannels are from 10 to 20 per cent. lower than in bituminous coals. He states also that "If the analyses of cannel coals were used the maps would tend to show areas of low fixed carbon content in the regions where there was much cannel coal. As those areas would not indicate regions of low regional alteration, they would greatly detract from the value of the map." He also states that "While

the isocarb map has an important use in predicting the best areas for testing it should be understood that it merely gives an indication of one of the conditions necessary for the occurrence of oil and gas. If source rocks and porous reservoirs are not present there will, of course, be no production no matter how ideal the isocarbs are. On the other hand, if the isocarbs are extremely unfavourable, there should be no oil or gas production even though other favouring conditions are present." This is the same conclusion I had stated in other words in my Queensland Report written in February of the same year, so that Mr. Russell and myself had reached two exactly similar conclusions at the same time while working in quite different fields.

Thus, the dome-like areas to the north-west of the Sydney Basin do not appear so favourable when they are carefully scrutinised in detail. The conditions must, however, be considered favourable for the occurrence of natural gas and boring is being undertaken to test the most suitable areas. It is possible that comparatively small accumulations of oil may be found where conditions have been especially favourable for retention.

(*g*) *Other parts of Australia.*—I have now dealt with the more important areas in which research work with regard to the finding of supplies of Petroleum has been carried out. A great part of Australia has not yet been geologically examined or mapped, equally large areas have only been covered by rapid reconnaissance surveys. It is estimated that only about one per cent. of the Continent has been mapped in such detail as our British maps show. I doubt if it is as much as that. It is therefore possible that there may be areas of equal or greater interest than those dealt with. A good deal of prospecting and even drilling has been carried out in areas other than those described but such areas are of much less interest, and have as a rule little to commend them as potential oil producing areas.

(*h*) *Kerosene and Oil Shales.**—In the Permo-Carboniferous Coal Measures west of Sydney, one of the finest kerosene shale deposits in the world exists. The probable reserves in the Capertee-Wolgan-Glen Alice area alone are estimated at approximately 20 million tons The seam varies from 14 inches to 50 inches in thickness, and the yield of crude oil per ton of shale obtained by distillation on a commercial scale exceeds 100 galls. In the Wolgan Valley a large distillation and refining plant has been erected, but it has been idle for some time. The rising costs during and since the war, serious and protracted labour troubles, together with the strenuous competition

* See Paper 6, pp. 15 et seq. Page 31.

from importing oil companies has combined to make it unprofitable to work these deposits. There is, however, some hope that the mines and works will be reopened at no very distant date, and if labour troubles can be avoided and modern labour-saving methods adopted, these deposits should be a source of petroleum products that will go a long way towards providing the internal supply for which Australia is seeking.

Another interesting body of shales exists in Northern Tasmania on the Mersey River, near the old mining town of Latrobe. In this case, the shales are found in strata of Mesozoic age deposited in comparatively small isolated basins in Palæozoic or older rocks. The shale is unusual in appearance. It is brown in colour and composed of what are regarded as spores, which are visible to the naked eye, giving the rock a granular appearance. The beds outcrop at the surface and are never very deep at the centres of the basins. They can be worked at most placed without the sinking of shafts. The seam varies from 4 ft. to 7 ft. in thickness, with a good roof above. Distillation yields amount of over 40 galls. of crude oil per ton, together with about 11 galls. of spirit and a quantity of fixed gas. The crude oil is remarkably high in calorific value, and is eminently valuable as a fuel oil. Although the companies working these deposits have had a long and difficult struggle against adverse conditions, they seem to have turned the corner and the work of development is now being pushed ahead. One company has erected a new kind of combined retort and cement kiln. The waste gases from the retorts are used to assist in firing the kiln, while the waste heat from the kiln is used to assist in heating the retort, a kind of circular process. It has been found that the spent shale makes a very good base for cement making, while an excellent limestone is found close at hand. The Tasmanian Government, as well as influential business concerns, are interesting themselves in the development of these oil shales and great efforts will be made to turn them to account for local requirements.

4. *Other Opinions and Conclusions.*

On broad lines of geological history, some authorities on Petroleum have come to the conclusion that supplies of oil are not likely to be found in Australia. For example, White and Schuchert have stated* that Australia is "not especially rich in marine deposits, and when these are present they have been subjected to mountain making to such an extent that all the volatile hydro-carbons have long since vanished into the air or been transformed into fixed

* David White and Charles Schuchert, "Genetic Problems affecting Search for New Oil Regions." Petroleum and Gas. American Institute of Mining Engineers, 1921.

carbon." They also state that Australia is a continental nucleus or "shield" and therefore has hardly at any time been under the sea. Now it is dangerous to generalise thus for a Continent, and errors or part errors are included in this statement. While it may be true in a general way to say that Australia is not especially rich in marine deposits there are areas in which such deposits are of considerable importance and thickness. Moreover, in such cases, any evidence that these beds have been much subjected to mountain making is conspicuous only by its absence.

E. C. Andrews, head of the Geological Survey Department of New South Wales, on the other hand, draws attention to the absence of marked folding in the Post-Palaeozic sediments and refers to the lack of alteration in sediments from Cambrian times.* At the same time, he lays stress on the general absence of such evidences of the existence of Petroleum as would attract the notice of the old time prospectors who did such excellent pioneering work in other directions. He also notes that most of the important oilfields of the world are situated in the Geo-Synclines paralleling the curves, arcs, or zones of great mountain building folds, and that such conditions do not exist in Australia. On these grounds he is not optimistic as to the chances of finding oil in Australia, but thinks that if commercial pools do exist they will be found in formations older than the Tertiary. This is, I think, a reasonable opinion based on first hand and practical knowledge of the geological conditions existing in Australia.

On the other hand, a number of authorities at the request of the Government of Queensland gave opinions based on the discovery of large volumes of wet natural gas at Roma and the geological conditions as revealed by the logs of the bores at that place.† Most of the writers were optimistic as to the chances of finding oil in this part of Queensland, and favoured the continuation of the work of prospecting and drilling.

Thus, there is come conflict of opinion. Opinions based on broad generalisations are on the whole unfavourable. Those based on conditions existing in particular areas are inclined to be favourable. This is perhaps what might be expected from the nature of the Australian Continent. Very large areas are distinctly unfavourable for the occurrence of Petroleum, but the close study of a few areas

* "Prospecting for Petroleum in Australia," Economic Geology. Vol. XIX, No. 2, March, 1924.

† W. E. Cameron, "Petroleum and Natural Gas Properties at Roma. Also Reports and Correspondence on Prospects for Petroleum and Proposals for Development," by Sir Boverton Redwood, Bart., Sir Thomas Robinson, K.C.M.G.; Dr. A. C. Veatch, Wm. Hope Henderson, M.I.M.M., P. Charteris, A. Stewart, W. H. Dalton, F.G.S., F.C.S., Lionel C. Ball, B.A., B.E. (Syd.) Queensland G.S. Publication No. 247.

of comparatively limited extent leads one to the conclusion that commercial pools of oil do occur elsewhere in association with conditions which are not unlike those which exist in these places, and that such factors as may militate against possible accumulations of oil in these areas are not the absence of normal necessary conditions for formation, accumulation and preservation, but the presence of abnormal factors which operate locally and are not usually active in productive oilfield areas. Australia, however, cannot afford to leave the matter in doubt. The need for internal supplies of oil is pressing, and those areas which are most favourable by reason of the nature of the sedimentary accumulations and geological structures will be tested in the only satisfactory manner that is available to us, that is by drilling.

LIST OF OFFICIAL REPORTS BY THE AUTHOR ON AREAS IN AUSTRALIA AND PAPUA.

1. "Petroleum in Papua." Commonwealth Government Parly. Paper. Melb. 1914.

2. "The Supposed Oil-bearing Areas of South Australia." Geol. Surv. of S.A. Bull. No. 4, 1915.

3. "Petroleum Prospects on Bruny Island." Tasmanian Govt. Parly. Paper. Hobart, 1915.

4. "Report on the Financial Position, Requirements and Prospects of the Railton-Latrobe Shale Oil Company." Tasmanian Govt. Parly. Paper. Hobart, 1916.

5. "Petroleum Prospects, Kimberley District of Western Australia and the Northern Territory." Comm. Govt. Parly. Paper. Melbourne, 1924.

6. "The Possibility of Oil Discovery in Queensland." Comm. Govt. Parly. Paper. Melbourne, 1925.

7. "Petroleum, Report on Investigations made in New South Wales." Comm. Government Parliamentary Paper. Melbourne, 1925.

8. "Report on Petroleum Prospects in Parts of Western Victoria, South Australia and Western Australia." Comm. Govt. Parly. Paper. Melb., 1926.

9. "The Wade Collection of Fossils." Preliminary Report by F. Chapman, F.L.S. Commonwealth Government. 1926.

DISCUSSION.

The President was sure the members would sympathise very much with the Commonwealth Government which had so many difficulties to face in searching for oil, particularly the appalling field difficulties which must face the prospector. Among those difficulties the Commonwealth officials had to face some of the optimists to whom the author had referred. There could be no possible doubt in regard to the importance of finding petroleum on a commercial scale in Australia, and it was quite natural that

the Commonwealth Government should spare no possible effort in its search for supplies. After all, in Australia there was a very big area and a very small number of intelligent observers, while it was well known that a very important oil-field could hide in a very small jungle or be covered by a limited stretch of sand; so that there was some justification for the Commonwealth Government spending money as they did, some people might think wastefully at times, in the desperate search for oil. The importance of making each distinct part of the Empire self-contained in the matter of essential raw materials was brought home to this country during the War. Another lesson learned during the War was that no country and no Empire, not even the United States, was completely self-contained so far as its mineral necessities were concerned; they were all dependent on one another in a way that some politicians seemed to forget when they pushed home the policy of self-determination. The developments of modern engineering had made oil so absolutely vital to industrial activities, and therefore to military safety, that Australia in its isolated condition, far away from other sources of supply and from other important parts of the Empire, must naturally make a very desperate effort in its search for oil. He hoped the author would be able to answer without trouble a question that occurred to him when he was dealing with the Pre-Cambrian, or rather the so-called lower Pre-Cambrian rocks which were supposed to be fossiliferous. From the photographs which had appeared in previous papers published by the author, the fossils appeared to be rather of the sort that had been found in Pre-Cambrian rocks elsewhere, for instance, the supposed Pre-Cambrian rocks of India and in the Belt series of America. He would like to ask more specifically whether the *Olenellus* which had been relied on as the base of the Cambrian had really been critically examined. There was a very fine display of what was once supposed to be a Pre-Cambrian fauna in the Salt Range of the Punjab, until some years after its announcement it was discovered that the *Olenellus* was another genus altogether, which had its nearest relatives elsewhere in Middle Cambrian rocks. With reference to the area of the Ord basin referred to by the author, where the rocks were pointed out as containing fossiliferous structures, and the rock horizon was spoken of as 12,000 ft. below the *Olenellus* stage, he presumed that included the 3,000 ft. of basalt.

Dr. Wade replied in the affirmative.

The President said he only desired to put those questions with the object of knowing to what extent the fossils had been critically examined, because geologists were always on the look-out for a

pre-*Olenellus* fauna, but so far none of them had been as satisfactory as they might be. He was sure the members would desire him to convey to the author the thanks of the Institution for his very interesting paper, for bringing for their inspection such a large collection of specimens, and for the slides which had been shown on the screen.

Dr. J. A. L. Henderson said the paper was extremely interesting to him as twenty-six years ago he spent two or three years in Australasia, when he looked into the oil possibilities of Australia, Tasmania, and New Zealand. Ever since that time he had followed with great interest the geological and drilling research work which had been done, particularly that associated with the author. It appeared to him very extraordinary that an enormous sedimentary basin such as that of Queensland and East-Central Australia should be occupied solely by fresh water beds. He would like to know whether the evidence was conclusive to that effect to the greatest depths thus far penetrated in boring operations. In any case, if such widespread fresh water seas were possible, could it not be equally probable that petroleum, if the usual theories of origin be assumed, should be found in its sediments. He saw no reason why that should not be so, especially as natural gas was found abundantly throughout the basin, of a distinctly petroleum type, in addition to evidences of bitumen and liquid petroleum.

Reference had been made by him in a paper read before this Institution in 1916 (Vol. II., 195—226), to the Great Artesian Basin of Australia, and its possibilities, drawing attention to the equally extensive artesian basin of the Rocky Mountain oil-and gas-bearing region of North America of somewhat similar character and age. It still appears evident that as a preparation for the study of the petroleum possibilities in the Australian basin, a careful geological survey of that great area is necessary, in order to furnish information as to structural conditions and variation in character of the sediments. Exploratory drilling could thereafter properly follow.

Mr. E. H. Cunningham-Craig said that Dr. Wade had covered a very large field, and tackled a number of very diverse problems with great success.

As regards the bitumen found along the shores of Southern Australia, a very similar phenomenon could be observed on the south-western end of Tobago. In the latter case, it was supposed that there might be an outcrop of oil-bearing strata beneath the sea, and some unsuccessful drilling was done on land to discover whether any deposit of oil rock extended inland. The bitumen was thrown up by the waves on to coral rock, and, being in a plastic or semi-liquid state, it adhered to the coral, but other specimens of the

bitumen as it dried up and inspissated were rolled into pebbles on the shore, and during this process the bitumen got to some extent contaminated with sand. It appeared probable now that this bitumen came from submarine oil seepages off the east coast of Trinidad, and was brought by currents round the north-eastern extremity of Trinidad, and finally washed up on the shores of Tobago. It was possible that in the Australian case sticky oil and bitumen might be brought an even greater distance by ocean currents to where it was found in Southern and Western Australia.

The bores at Roma and other localities in Queensland were certainly very interesting, and he (Mr. Cunningham-Craig) had had a lengthy correspondence, lasting several years, with Mr. Cameron and others upon the subject. There seemed to be no doubt that Mesozoic strata did reach the oil-bearing stage, but that, for want of a structure suitable for concentrating the oil, it gradually became absorbed and dissipated, leaving only the heavier residues, such as were brought up in small quantity in the hot water, and gas. Unless some favourable structure for concentrating oil could be discovered in these strata, there was no hope of finding an oilfield.

The dome structure shown by Dr. Wade in the Triassic coal measures might have some slight chance of having preserved liquid petroleum. In North Staffordshire, where seepages of petroleum were found at three or four horizons low down in the Coal Measures, the upper Coal Measures contained a number of bands of torbanite, one of which at least was very rich, while others, though not so rich, were very fresh and little inspissated. This showed that oil producing conditions were approached, if not actually attained. The occurrence of very rich torbanites in the coal measures of Australia showed also that the oil-producing stage was approached, and it was possible that in the deeper measures some liquid petroleum might still be found.

The resemblance between Australia and South Africa had very frequently been remarked upon. Both countries had a central massif of very old rocks, while the younger strata occurred more as marginal selvages, not very greatly affected by movement. The glacial till, the coal measures and the dolerites in each case were of the same age. It appeared also that in the search for oil Australia resembled South Africa, but in South Africa the prospectors had more excuse for their activities, since over a great part of the country the dolerite dykes and sills had distilled oils out of strata of the Karroo series. These evidences of petroleum varied from very light oil to heavy solid bitumen, which latter was found mostly in vesicles. Occasionally signs of oil were found in the sedimentary rocks in contact with dolerite sills and dykes, but in all these cases these phenomena were the results of natural distillation caused by

the heat of the intrusive rocks. Drilling for oil had been carried out in very many localities, and in one case after passing through the Karroo strata the bore was carried some 3,000 feet further into metamorphic granite. Australia could perhaps hardly show such an example of the way in which money could be spent searching for oil without sufficient knowledge of the subject.

Dr. Wm. Hope Henderson said that the author seemed to indicate that those enormous areas of Queensland and the Northern Territory, previously considered to be a widespread formation composed of Upper and Lower Cretaceous rocks, must now be placed in the Pre-Cambrian, as the outliers of the Desert Sandstone were chiefly quartzites of Pre-Cambrian age. He would like to know whether this was a correct interpretation of the author's views.

Referring only to the Queensland developments for oil, he found there were 36 wells marked on the author's map, but evidently a number of these were water-wells. He thought it would be of interest to hear how many of these bores were actually started and drilled as test-wells for oil, and of these, what number had been sunk by experienced oil-well drillers and successfully completed with reliable water shut-offs, and the various indications given proper tests, as he had found no satisfactory records dealing with these points.

With regard to the natural-gas from the wells, the analysis of No. 2 bore gas showed 9 per cent. Ethane and heavier hydrocarbons, whereas No. 3 bore gas contained only 6 per cent. of such condensible products. He thought it would be of value to know how often samples for analysis had been taken, and whether the gas showed progressive increase in the heavier hydrocarbon content, as this might form an important indication. In his paper the author mentions the gas from Roma No. 3 well as containing 1¼ "pints" of gasoline per 1,000 cub. ft., and in his report to the Government it is given as 1·2 "units" of gasoline, whereas Dr. Jensen refers to 1·2 "parts" of petrol. Are pint, unit, and part interchangeable values, or on what basis is the unit and part calculated. The gas is termed "wet," but in usual practice it would be a "dry" gas.

In reference to the logs of the wells, the author suggests that there is no horizon which can be called constant, but it appears from the recorded sections of the wells around Roma, that several horizons exist which would be considered satisfactory markers in oil-well drilling practice.

The author considers the water in the Lower Walloon series to be fresh water, and evidently in 1923 Dr. Jensen also held this view, but in his publication of January of this year, Dr. Jensen

repeatedly alludes to the salinity of these waters, stating these to be very saline and in association with other mineral contents, which render them favourable for oil, and he regards them of salt or brackish water, relic sea, deposition, with the suggestion that the result of the Lander bores, may dispel the fresh water theory. He (the speaker) hoped that the author might be able to explain this point.

It was interesting to learn from official publications that the Government of Queensland had sought the advice of several authorities on the best procedure for testing-development for oil, but the opinions differed entirely. The one side advised a careful detailed geological study on the surface before selection of any locations for wells, and further, that water-well drillers would be quite satisfactory ; the other side insisted on only experienced oil-well drillers being employed, and advised the immediate sinking of a series of wells to secure positive evidence. This diversity of opinion may have been responsible for the inconclusive results obtained, and the absence of greater knowledge on the possibilities of oil in Queensland at the present time. It must be recognised, however, that the total prospecting for oil in Australia has been most limited, and when one considers that during 1925 in Mexico 772 wells were drilled, and of these 545 were failures, it may suggest to those concerned what enterprise exists in the search for petroleum.

Mr. E. Parsons said he was particularly interested in the group of fossiliferous pre-Cambrian rocks found in Northern Australia. He would like to inquire if the fauna of those particular rocks had been examined in great detail, and whether they showed any affinity to any particular horizon of the Cambrian elsewhere. It appeared to him from the section shown on the screen that it might be possible that there was a break in the strata (a sort of roll). The quartzite wall rather indicates such a break ; and that really what was represented was not a pre-Cambrian group but a later group which had been brought into a different position by the roll. Was any detailed mapping done which would throw light on this ? Such work alone would prove the assertion.

On the Northern Frontier of India there was a similar group of rocks which many people considered to be of Cambrian age underlying Tertiary rocks. When they were mapped in detail it became quite clear that such was not the case, but that the so-called Cambrian rocks were altered Tertiary rocks which had been brought into that position by over-thrusting. In other places there were Tertiary rocks resting on undoubted Cambrian rocks as proved by the fossil contents of those rocks.

Dr. Arthur Wade, in reply to the President's question whether the *Olenellus* had been critically examined, said that the fossils of the area in question were examined by Mr. F. Chapman, the palæontologist of the National Museum in Melbourne, whose report is referred to in the list of works quoted at the end of the paper. In addition to *Olenellus* other types, such as *Redlichia*, characteristic of the Lower and Middle Cambrian, were also discovered. With regard to the so-called Jurassic beds of Northern Queensland, since writing his report on the Northern Territory and Western Australia areas, drawing attention to the fact that some of the strata in Queensland were likely to be Cambrian in age, trilobites of the *Olenellus* type had been found in an area formerly supposed to be occupied by strata of Jurassic age. With regard to the Ord Basin, first of all there were 3,000 ft. of basalt, and then a tremendous thickness of quartzites, limestones and flagstones. Further south Hardman estimated a thickness of 12,000 ft. without basalt. There was, therefore, a great thickness of those beds below the *Olenellus* zone, and in places the beds contained fossils, the nature of which was at present very obscure. Dr. Henderson had asked a question with regard to the fresh water beds. Personally he did not think there was any question that the Jurassic beds of both Queensland and New South Wales were of fresh water origin, and he thought Prof. Sir Edgeworth David, who was now in London, would fully bear out that statement. He did not think there could be any doubt, either that petroleum could occur in such beds, especially in view of the discoveries of petroleum in rocks of very similar origin and character in the Rocky Mountain foot-hill region, where of late years there had been considerable development of oilfields from fresh water series. If the area of fresh water deposits was large, and the accumulation of deposits considerable, he did not think there was any reason why petroleum should not be discovered in such deposits, in fact they had been discovered in such deposits in the area referred to.

In reply to Dr. Hope Henderson, one of the most important questions was what had become of the Cretaceous in that part of Australia. A good deal of that Cretaceous had disappeared when Jensen published his last map of the Northern Territory, and in one of his later bulletins the so-called "Desert Sandstone" was shown to belong to at least four different periods ranging from Cambrian up to Recent. The Desert Sandstone was not necessarily Cretaceous except where there was a definite sequence as in some parts of Queensland. A great many different sandstones had been so-called. There is at present no evidence whatever that any large part of the Northern Territory is covered by strata of Cretaceous age.

With regard to the bores in Queensland some were definitely drilled for oil, though the greater number were drilled for water. Those drilled for oil in most cases were drilled by American drillers, and in some cases under American supervision. Quite efficient methods were therefore adopted for testing the strata as drilling proceeded. A good many of the bores were water bores, in which traces of oil and gas had been found in boring.

With regard to Roma analyses of the gas were almost invariably done by the Government analyst. Very many analyses had been made, and I believe, at regular intervals. In some cases the bores ran into gas unexpectedly. The figures with regard to the amount of gas extractable from a definite quantity of the gas were supplied by the Government Analyst of Queensland. I am obliged to Dr. Wm. Hope Henderson for drawing attention to an inaccuracy in the part of the paper dealing with Queensland. No appreciable amount of gas was met with at Roma until the No. 2 well was drilled in 1900. Dr. Henderson thinks that the top of the bores at Roma show horizons which are sufficiently constant to be used as "markers." In the Roma bores it was impossible to trace one coal seam definitely from one bore to another. All one could be certain of was that between certain limits one was likely to get coal seams; even these strata were very inconstant over short distances.

As for the gas itself nobody knew even to-day exactly from which horizon the gas came. In the case of the later deep bores put down at Orallo, a few miles N. of Roma, attempts made to correlate horizons in bores only short distances apart had resulted more often in disappointment than otherwise.

The water obtained from these borings could not be called a salt water. It was certainly heavily mineralised, but it was good for stock. Cattle and sheep drink it, and even human beings had to live on it at times. It was not a salt water in the real sense of the term. It was not like the salt waters usually obtained in connection with oil boring.

With reference to the question of detailed surveys it was quite true that a good deal of detailed geological survey work was necessary. In Australia such survey work was very rare.

In reply to Mr. Parson's question, there was no doubt about the position of the strata as shown in the section. They were definitely lower than the fossiliferous Cambrian. If one were to rely purely and simply on one section the matter might be open to some doubt, but many sections from Halls Creek, across to the Gulf of Carpentaria, gave confirmation. Hardman's sections closely resembled the one shown, and some of Hardman's work at least could be described as detailed. The fossils obtained from the lower strata

had very definite resemblances to proterozoic fossils described by American observers, especially Dr. Walcott, which also tended to support the views expressed by the author. Strata of similar types and apparently in the same stratigraphical position occupied very extensive areas in WesternA ustralia, and had been described by many well-known geologists, including Gibb Maitland and Prof. Sir Edgeworth David. It was very generally held that such strata were older than the lowest fossiliferous Cambrian strata in Australia.

The President, on behalf of the Council and Members, thanked Dr. Wade for his paper and his concluding remarks.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

ANNUAL REPORT OF THE COUNCIL FOR 1925.

THE Council has pleasure herewith in presenting their Annual Report for the year ended December 31st, 1925, together with the Accounts for that period.

The net increase in membership during 1925 was 67, the changes during the year and the total in each class on December 31st, 1925, as compared with 1924, being :—

	TOTAL 31.12.24.	CHANGES DURING 1925.							TOTAL 31.12.25
		New.	Transferred to.	Resigned.	Deceased.	Names removed.	Transferred from.	Net gain.	
Honorary Members	9	2	—	—	1	—	—	1	10
Members	382	31	9	5	4	10	—	21	403
Associate Members	182	38	17	2	1	5	8	39	221
Students	118	26	—	6	—	2	16	2	120
Associates ..	38	9	—	3	—	—	2	4	42
TOTALS ..	729	106	26	16	6	17	26	67	796

In addition, 21 prospective Members were awaiting election at that date, and 26 newly-elected Members had not then ratified their election.

In presenting the Accounts for the year ended December 31st, 1925, the Council are glad to state that the Balance Sheet continues to show a satisfactory financial position. The Capital of the Institution amounts to £1,855 7s. It was decided to continue the Award of the Scholarships for the year 1925, amounting to £80, out of the funds of the Institution, as hitherto they had been from a special grant.

The Institution is represented on the American Society for Testing Materials; the Advisory Board of the Department of Oil Engineering and Refining of the University of Birmingham; the British Association for the Advancement of Science; the British Engineering Standards Association; the Fuel Economy Committee; the Imperial Mineral Resources Bureau; and official representatives also attended the International Congress of Drilling Technologists, Bucharest, September 26th to October 8th, 1925,

and the Fifth Congress de Chimie Industrielle and Commemoration de l'Industrie de la Stearinerie, Paris, September 27th to October 11th, 1925.

Eight General Meetings of the Institution were held during 1925, at which the following papers were read and discussed :—

Eighty-second General Meeting, January 6th: "The Behaviour of Lubricating Oils under Oxidising Tests," by J. B. Hoblyn.

Eighty-third General Meeting, February 3rd: "Hydrogenation in the Petroleum Industry," by H. I. Waterman and J. N. J. Perquin.

Twelfth Annual General Meeting, March 10th: "The Uses of Petroleum with Special Reference to the Production of Power," by H. Barringer (Valedictory Address).

Eighty-fourth General Meeting, April 7th: "Vapour Pressures of Binary and Ternary Fuel Mixtures," by J. Stanley Lewis.

Eighty-fifth General Meeting, April 23rd: "The Present Status of the Oil-Shale Industry in Estonia," by P. N. Koggerman.

Eighty-sixth General Meeting, May 5th: "Some Notes on Water Shut-Off," by F. G. Rappoport.

Eighty-seventh General Meeting, October 13th: "Notes on the Geology of Java," by Ernest Parsons.

Eighty-eighth General Meeting, November 10th: "The Principles of High Vacuum Distillation of Mineral Oils," by Leo Steinschneider; "The Determination of Unsaturateds in Petroleum Spirit," by W. R. Ormandy and E. C. Craven; and "Determination of the Molecular Weight of Petrol," by W. R. Ormandy and E. C. Craven.

Eighty-ninth General Meeting, December 15th: "The Selection and Properties of Steels Used for Oil-Well Boring Equipment," by J. H. S. Dickenson, B. Grey and F. E. Cherry.

The London and Birmingham Branches of the Students' Section have held 8 and 7 Meetings respectively during 1925, at which papers on various subjects pertaining to the Petroleum Industry were read and discussed.

Six numbers of the Journal were published during the year. These contained, in addition to the papers read before the

Institution, a number of contributed articles on various phases of petroleum technology, and Journal No. 51 was devoted to the Reports on the Progress of Naphthology during 1924. It has been decided that in future the publication of the Current Bibliography shall be discontinued in order to allow of more space being devoted to Abstracts, and the Council desire to record their thanks to Mr. W. J. Wilson for his valuable services in the compilation of the Bibliography.

Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., has been unanimously re-elected President for the ensuing year.

The Rt. Hon. Viscount Cowdray of Cowdray, Sir John Cargill, Mr. Alfred C. Adams, Mr. Alexander Duckham, Mr. Arthur W. Eastlake and Mr. Robert Redwood have been unanimously re-elected Vice-Presidents, and Dr. W. R. Ormandy has been unanimously elected a Vice-President for the ensuing year.

The Redwood Medal for the Sessions, 1923-24 and 1924-25, has been awarded to C. H. McCarthy-Jones for his paper on "Electricity Applied to the Winning of Crude Petroleum, with Special Reference to the Yenangyoung Field, Burmah," which was read before the Institution on February 12th, 1924.

The Students' Medal and Prize for the 1924-25 Session has been awarded to E. Clark, Royal School of Mines, for his paper on "Organic Theories of Oil Origin," which was read before the London Branch of the Students' Section on January 20th, 1925. The Scholarship at the Royal School of Mines was awarded to J. O. Tanner and at the University of Birmingham to C. J. Ward.

The Library Committee report that an addition of 400 volumes was made to the Library during 1925, making a total of 1,205 books, exclusive of unbound periodicals, catalogues and maps. The Council is indebted to many donors for generous gifts of books, particularly to Mrs. Stewart, on behalf of her son, the late Mr. P. C. A. Stewart, to Messrs. The Spies Petroleum Co., Ltd., and to Mr. Robert Redwood. During the year the Library was consulted by about 200 persons, an estimated increase of 50 per cent. over the previous year.

A Committee was appointed by the Council to consider the alteration of certain By-Laws, and the recommendations of this Committee, as approved by Council, are set out below:—

Section II., para. 1.—Delete Definition of Petroleum and insert: "The word Petroleum is accepted in the widest sense, and includes all natural bitumens and hydrocarbons derived from any source from the lightest gaseous state through the varying densities of liquid to the various solid forms."

Section III., para. 3, *lines* 8 *and* 9.—Delete: "And is so engaged at the time of his application"

Para. 4, *lines* 10 *and* 11.—Delete: "And he shall be so engaged at the time of his application"

Para. 6, *lines* 4 *and* 5.—Delete: "Shall be not less than 30 years of age, and"

Section IV., para. 12, *lines* 1 *and* 3.—Delete "four-fifths" and insert "nine-tenths" in each case.

Para. 13, *line* 1.—Delete: "11" and insert "50"

Para. 18, *line* 2.—Delete: "One year" and insert "two years"

Para. 18, *line* 3.—Delete "Six" and insert "three"

Section VI., para. 2, *line* 3.—Insert: "Or Associate" after "Associate Member"

Section VIII., para. 2, *line* 9.—Insert: "And of all Committees" after "Council"

Form D, line 6.—Delete: "Six" and insert "three"

Members and guests to the number of over 200 were present at the Seventh Annual Dinner, and the attendance at the Con-Conversazione and Exhibition of Apparatus at Aldine House on October 6th, 1925, was about 150.

It is with deep regret that the Council have to announce the deaths of six members, namely:—F. W. Bishop, Dr. David T. Day, H. W. G. Duthy, E. B. Forbes, F. W. Moon and G. B. Reynolds.

The courtesies extended to the Institution by the Royal Society of Arts in allowing the use of their House for meetings, and by the Chemical Industry Club in permitting Members of the Dinner Club to dine at, and use, their premises, have been continued during the period under review, and the Council desire to place on record their thanks for, and appreciation of, the action of these bodies.

For valuable services rendered, the Council wish to express their appreciation and thanks to Sir William Plender, Bart., G.B.E., Honorary Treasurer; Messrs. Ashurst, Morris, Crisp and Co., Hon. Solicitors; Messrs. Price, Waterhouse and Co., Auditors; Dr. A. E. Dunstan, Honorary Editor, and his Assistant, Mr. George Sell; and to the Secretary, Commander R. E. Stokes-Rees, R.N., and his Staff.

The Auditors retire and offer themselves for re-election.

By Order of the Council,

ARTHUR W. EASTLAKE,
Honorary Secretary.

REVENUE ACCOUNT for the year ended 31st December, 1925.

Dr.	£	s.	d.
To Salaries	884	6	6
„ Rent, Rates, etc.	453	18	3
„ Printing and Stationery	125	3	7
„ Postage	132	16	4
„ Hire of Hall for Meetings and Expenses of Meetings	205	17	6
„ Journals	348	11	1
„ Income Tax on Interest and Dividends paid without Deduction	15	12	0
„ Auditors' Fees	10	10	0
„ Students' Prize and Scholarship Fund	80	0	0
„ Sundry Expenses	219	7	2
„ Depreciation of Office and Library Furniture ..	25	13	4
„ Balance as per Balance Sheet	523	17	8
	£3025	13	5

Cr.	£	s.	d.	£	s.	d.
By Subscriptions—						
Members	1916	15	6			
Special	901	5	0			
				2818	0	6
„ Interest and Dividends				110	18	10
„ Sale of Books				96	14	1
				£3025	13	5

STUDENTS' PRIZE AND SCHOLARSHIP FUND.

1925.		£	s.	d.
Dec. 31.	To Scholarships Granted—			
	Royal School of Mines	40	0	0
	Birmingham University	40	0	0
	„ Balance carried forward	20	0	0
		£100	0	0

1925.		£	s.	d.
Jan. 1.	By Balance brought forward	20	0	0
Dec. 31	„ Revenue Account	80	0	0
		£100	0	0

STUDENTS' SECTION FUND.

1925.		£	s.	d.
Dec. 31.	To Expenses for the Year	7	3	10
	„ Balance carried forward	75	3	2
		£82	7	0

1925.		£	s.	d.
Jan. 1.	By Balance brought forward	82	7	0
		£82	7	0

BALANCE SHEET as at 31st December, 1925.

LIABILITIES.

	£ s. d.	£ s. d.	£ s. d.
To Capital of the Institution, under Bye-Law Section 6, para. 14, viz. :—			
Life Membership Fund, as per last Account		413 0 0	
Entrance Fees—			
Per last Account	976 9 0		
Additions during year	139 13 0		
		1116 2 0	
Donations per last Account ..		326 5 0	
			1855 7 0
„ Students' Prize and Scholarship Fund			20 0 0
„ Students' Section Fund			75 3 2
„ Subscriptions paid in Advance ..			220 10 0
„ Entrance Fees paid in Advance (pending election)			4 4 0
„ Sundry Creditors			329 7 2
„ Revenue Account—			
Balance 31st December, 1924 ..		1367 6 6	
Less : Arrears of 1924 Subscriptions written off		40 8 6	
		1326 18 0	
Add : Balance for year as per Revenue Account, 1925		523 17 8	
			1850 15 8
			£4355 7 0

ASSETS.

	£ s. d.	£ s. d.
By INVESTMENTS AT COST—		
On Account of Capital—		
£664 6 6 London County 3% Consolidated Stock	481 10 6	
£925 0 0 5% War Loan, 1929-47.. ..	862 18 4	
£50 0 0 National War Bond 5%, 1927..	50 0 0	
£150 0 0 Birmingham Corporation 6% Stock	146 16 0	
£350 15 7 Conversion 3½% Stock	275 0 0	
		1816 4 10
(Market value, £1805 6s.)		
On Account of Revenue—		
£500 0 0 5% War Loan, 1929-47.. ..		501 19 6
(Market value, £502 10s.)		
„ OFFICE AND LIBRARY FURNITURE (excluding presentations)—		
As per last Account	502 9 2	
Additions during the year	10 16 6	
	513 5 8	
Less: Depreciation at 5%	25 13 4	
		487 12 4
„ LIBRARY (BOOKS) (excluding presentations)—		
As per last Account	143 11 10	
Additions during the year	34 16 0	
		178 7 10
„ SUBSCRIPTIONS (1925) OUTSTANDING at date and considered collectible		80 10 6
„ SUNDRY DEBTORS AND PAYMENTS IN ADVANCE..		212 2 5
„ CASH ON DEPOSIT		965 1 2
„ CASH AT BANK AND IN HAND		113 8 5
		£4355 7 0

J. S. S. BRAME.
W. R. ORMANDY, } Members of Council.

We have examined the above Balance Sheet with the books of the Institution, and having obtained all the information and explanations we have required, we are of the opinion that such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institution's affairs, according to the best of our information and the explanations given to us and as shown by the books of the Institution.

PRICE, WATERHOUSE & Co.,

3, FREDERICK'S PLACE,
OLD JEWRY, E.C. 2.

20th January, 1926.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE THIRTEENTH ANNUAL GENERAL MEETING of the Institution was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2, on March 23rd, 1926, the chair being occupied by the President, Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S.

The Secretary read the notice convening the meeting, and the minutes of the last meeting were then read and duly signed as correct.

The list of members elected during 1925 was laid upon the table and the names of new members elected since the last General Meeting, as follows, were read :—

Members.—William John Clifford Cooke, William Archibald MacFadyen, Andre Paul Millot, Albert Leslie Robinson.

Associate Members.—Nicholas Lionel Anfilogoff, William Hunter, Walter Kauenhowen, Frank Levy, Frederick Williams Valle-Jones, Julius William Weil, Leonard Fairfax Whitfield.

Transference to Associate Members.—James Harris Park, Eric Blachford Woodrow.

Students.—Kamdhorn Devahastin, Robert Meyer Sturt Owen.

Associates.—Henry Edward Medlicott, Charles Henri Weiss.

In moving the adoption of the Annual Report, the President said the Report included two points to which he would like to call special attention. One was the increase in membership during 1925. Although they had lost some members, the Report showed a net gain of sixty-seven members during that year, and since the end of 1925 there had been a considerable number of new members elected. That progress could not be considered otherwise than satisfactory. Another feature in the Annual Report was the reference to the alteration of certain By-Laws. A Committee had been appointed by the Council to consider the alteration of some of the By-Laws, and the recommendations of that Committee, as approved by the Council, were set out in the Report. He would like to point out that in adopting the Report they were in no way committing themselves to the passing of those alterations, which would be dealt with separately.

Mr. G. Howell, in seconding, said they were in the progressive stages of the Institution. Their thanks should be accorded not only to their President, but to all the officers and Council, and particularly to Mr. Adams and staff for their work in connection with the accounts.

The Report was adopted.

The Secretary read the following reports from the two branches of the Students' Section :—

LONDON BRANCH.—The presentation of the Third Annual Report of the London Branch of the Students' Section marks the passing of another successful year.

Transference of Student Members to Associate Members balances with the admission of new members, the total membership being :—

	1924.	1925.
London ..	35	40
Country ..	25	26
Abroad ..	55	54

During the year eight General Meetings have been held :—

January.—Paper by Mr. E. Clark on "Organic Theories of Oil Origin."
February.—Second Annual General Meeting.
March.—Paper by Mr. H. R. Lovely on "Petroleum Indications."
April.—Paper by Mr. E. L. Bass on "Automobile Design in Relation to the World's Fuel Supplies."
May.—Paper by Mr. J. O. Tanner on "Emulsions."
October.—Paper by Mr. J. B. Kay on "Economics of Petroleum."
November.—Paper by Messrs. H. R. Lovely and F. P. C. Feilman on "Some Polish Experiences."
December.—General discussion on "Modern Production Methods."

The average attendance at the meetings has been between 10 and 15. These numbers should be improved on, but many students are attending evening classes.

The Students' Medal and Prize has been awarded to Mr. E. Clark for his paper, "Organic Theories of Oil Origin," and the Scholarship at the Royal School of Mines to Mr. J. O. Tanner.

In the Reports on the Progress of Naphthology, 1924, it is interesting to note that reference is made to Mr. C. A. Sansom's paper, "The History and Geology of the Oilfields of Mexico," and to Mr. A. B. Miskin's paper, "The Iodine Value of Cracked Spirits."

At the beginning of the 1925-26 Session an Excursion Secretary was appointed, and a visit to the Anglo-Persian Oil Company's

Research Laboratories, through the courtesy of Dr. A. E. Dunstan, was arranged. Further excursions are contemplated.

A Library, consisting of duplicates of certain books in the Institution's Library, has been donated to the Students' Section by the Council, from which books may be borrowed by Student Members. Periodic additions are contemplated, and the Committee tender their warmest thanks to the Council for this gift.

The Committee of the Students' Section desire to thank those senior members of the Institution who have consistently aided the Section by their attendance at the meetings.

(Signed) J. B. KAY,
Hon. Secretary.

(Countersigned) T. H. HOLLAND,
President.

BIRMINGHAM BRANCH.—Five meetings were held during the year, as follows :—

January.—Paper by Mr. G. Cotton on "Fire Problems in the Oilfields and Refineries."

February.—Paper by Mr. H. G. Shatwell on "Some Notes on the Bergius Process."

March.—Paper by Mr. G. C. K. Dunsterville on "The Restoration of Production in Abandoned Fields."

May.—Paper by Mr. Campbell M. Hunter on "The Vortex Motion in Oil Wells."

November.—Paper by Mr. G. T. Notley on "Some Notes on Our Recent Visit to Rumania."

All the above meetings were well attended and some interesting discussions took place.

In February a visit was paid to the Wire Rope Works of Messrs. J. and E. Wright, Birmingham, and drilling and other cables were seen in the various processes of manufacture.

In July and August five members of the Students' Section visited Rumania.

In October a Committee Meeting was held and the following elected as the Students' Section Committee :—

Chairman : H. V. Steadman.
Hon. Secretary : Launcelot P. Timmins.
Committee : G. T. Notley, R. G. Ffoulkes-Jones, M. Jaroslavici.

(Signed) LAUNCELOT P. TIMMINS,
Hon. Secretary.

(Countersigned) T. H. HOLLAND,
President.

The President said he would like on behalf of the Council to express their appreciation of the excellent work that had been done in the Students' Sections, and he commended to those members who could do so to attend as many of the meetings as possible. He was quite sure the Student Members would welcome any of the senior members of the Institution at their meetings. He had pleasure to-day in announcing an award, and if possible he hoped to confer that award on Friday, of a recognition supplementary to those mentioned in the Report. They would all have heard that Mr. E. Clark had been awarded the medal for what was adjudged the best paper of the year. The competition was so close that the Council felt justified in offering an additional prize of £5 for Mr. Garlick's paper on "The Chemistry of Petroleum." The £5 would be paid out of a fund placed at the disposal of the Council for purposes of that kind. He was sure the members of the Institution would be glad to know they were able to give some recognition to a paper that would have been good enough for the medal if there had been no paper from Mr. Clark available to compete.

Mr. Adams (Chairman of the Finance Committee), in moving the adoption of the Balance Sheet, drew attention to the fact that the first meeting of the Institution took place in the month of July, 1914, just before the commencement of the Great War. In comparing the accounts of to-day with those presented at the first and second Annual Meetings one was struck by the rapid strides made in bringing the Institution to the high position of influence and importance it enjoyed to-day. He thought everybody would agree that the accounts he had the privilege of proposing the adoption of to-day were eminently satisfactory. They showed the Institution was in a thoroughly sound and satisfactory position.

The accounts were in a form which was quite familiar to them all. From the Balance Sheet they would see that the capital of the Institution had been increased since last year by £139 13s., which represented the total of the entrance fees received from incoming members during the year, and which they had to invest. On the other side of the Balance Sheet was a statement of the investments showing that an amount of £1,816 4s. 10d. had been invested in various securities. A small balance of about £40 still remained in hand which would be invested as soon as the amount was further increased.

The items of "Students' Prize and Scholarship Fund," "Students' Section Fund," "Subscriptions paid in Advance," and "Entrance Fees paid in Advance" were, of course, all monies that they had

in hand, and were included in the Cash on Deposit shown on the other side.

The item of "Sundry Creditors" represented the ordinary outstanding accounts which were usually found in any concern at the time of balancing. Those amounts would become liquidated in the early part of the coming year.

Referring to the other side of the Balance Sheet they would notice that the Office and Library Furniture had been depreciated as usual, and the amounts shown for that item and for the books in the Library represented, in his opinion, a proper and fair valuation of those assets.

The item, "Sundry Debtors and Payments in Advance," consisted of amounts owing to the Institution, some of them for journals and advertisements which had not been paid for.

They would also observe that there was a quite substantial sum of Cash on Deposit amounting to £965 1s. 2d. In addition to that, however, there was another item on the credit side of the Balance Sheet which showed that they had invested the sum of £501 19s. 6d. in War Loan—being an investment made on account of revenue. The distinction between the first lot of investments, which were capital investments, and this particular item was that the sum of £500 could be realised and spent for the purposes of the Institution directly it was wanted.

The result was that they carried forward from Revenue Account to the Balance Sheet for the year a sum of £523 17s. 8d. So that the total of the Revenue Account now stood at £1,850 15s. 8d.

Turning to the Revenue Account, the items did not really need any explanation as they were quite of an ordinary character. He might, however, refer to the item of "Journals." The Journals cost the Institution in the year 1925 the sum of £348 11s. 1d. That item was arrived at by taking the actual cost of printing and issuing the Journal, and crediting or deducting from that item the revenue derived from the sale of Journals and advertisements. Having had occasion to refer to some of the earlier accounts of the Institution he had noticed in the very first set of accounts put before the members, covering the period from the inception of the Institution to December 31st, 1914, the amount received for the sale of the Journal was £2. The difference between that figure and the figure of between £300 and £400 which they now received from the sale of the Journal was striking.

This year they had also provided for the continuance of the Students' Prize and Scholarships, and the amount of £80 had been debited on account of those Scholarships.

The revenue from subscriptions was advancing as the membership increased. They would notice from the Report just adopted that

they were striving to approach the 1,000 mark, and he hoped it would not be very long before that object was attained.

Sir Frederick Black, who seconded the motion, said that when Mr. Adams informed them that the Balance Sheet was satisfactory it would be merely painting the lily to add anything to that statement. Mr. Adams on these occasions always treated them to that thoughtful criticism of the Balance Sheet which was so helpful to the members in understanding the position. But his colleagues on the Council recognised that it was not only once a year that Mr. Adams was dealing with the accounts, but all the year through, as Chairman of the Finance Committee, he was keeping them straight with his budgets of revenue and expenditure, and he could assure members that the Council never incurred any expenditure whatever without asking Mr. Adams his opinion as to whether it was justifiable and within their means. They owed a great debt to Mr. Adams for what he did for them in that most important branch of the working of the Institution—the financial branch.

The Balance Sheet was adopted.

The President moved amendments to By-Laws, of which notice had been given formally at the last General Meeting of the Institution, and previously for information.

The amendments, said the President, were in the view of the Council relatively small, but necessary. Unless any member wished to challenge the proposal he would move the whole of the amendments as one proposition after he had called attention briefly to what they were.

The first amendment was, in Section II., paragraph 1, a shorter but equally comprehensive definition of the word "petroleum." The reason for the amendment was that a Bill was being introduced dealing with the transport of petroleum, and they had embodied all the points that occurred in the Bill, as well as previously, with regard to the definition.

The second change proposed was in Section III., paragraph 3, where they proposed to delete the words "and is so engaged at the time of his application." That was because a man might be qualified in every way, but at the particular time of his application might be between two jobs. The same remark applied also to paragraph 4, lines 10 and 11, dealing with candidates for Associate Membership.

Then they wanted to open the door to Associates under thirty years of age, and hence the proposed amendment to delete "shall be not less than thirty years of age" in paragraph 6, lines 4 and 5. This was due partly to the fact that it was found there was a certain number of candidates who were suitable for the class of Associates,

but who, through the war and other accidents, had not had the foundation training which would qualify them for Associate Membership, though they otherwise showed qualities which, if they were admitted to the Institution, they might afterwards supplement and so qualify for transfer to full membership. It was therefore felt there was no necessity to limit the class of Associates to candidates over the age of thirty.

With regard to Section IV., paragraph 12, it was proposed to increase the proportion of votes required for election. At present the proportion stood at four-fifths, and it was desired to raise it to nine-tenths in order that the members should have a closer control over the kind of men admitted to the Institution.

Again, in paragraph 13 of Section IV., it was proposed to require for the future 50 votes instead of 11. The Institution, having increased in size, it would be only fair that a larger minimum should be adopted.

The other amendments were relatively small. It had been felt that by cutting a member off from the community for arrears of one year only might be very hard in some cases, because sometimes members were abroad and it was difficult to trace them in order to give them due notice. The period of grace was therefore proposed to be extended from one year to two years before a member was liable to be struck off the list. At the same time the period of final notice had been reduced from six to three months.

In Section VI., paragraph 2, it was proposed to insert "or Associate" after "Associate Member." That amendment had reference to the transfer fee. It was in conformity with the By-Law by which it was proposed to admit Associates at a lower age than thirty, and so in that way provide for their transfer to full membership if considered to be suitable when they attained the age of thirty.

By the amendment to Section VIII., paragraph 2, it was proposed that the Honorary Secretary should be a member of all Committees.

With regard to the amendment to Form D, line 6, if the change proposed with regard to the notice to be given to a defaulter was agreed to, then Form D, which was part of the By-Laws as sanctioned by the Privy Council, would have to be altered accordingly.

Unless any member wished to challenge the method of putting the amendments to the meeting he would like to save time by moving on behalf of the Council that the whole of the amendments be adopted.

Mr. Arthur W. Eastlake seconded.

Dr. Hope Henderson asked whether the effect of the alteration in Section VI., paragraph 2, would be to make an Associate trans-

ferable direct to full membership without passing through the status of Associate Membership ?

The President replied that the effect of the amendment was that he could be transferred direct. They were providing for the possibility of transferring a man from Associate to full membership. That had never been contemplated before, and therefore no provision had been made for charging the extra entrance fee ; but now with the possibility of such a transfer they were making provision for charging him the same entrance fee as he would have been charged if he had become an Associate Member first.

The motion was carried and the amendments adopted.

Mr. E. Parsons proposed that the retiring auditors, Messrs. Price, Waterhouse and Co., be re-elected.

Mr. W. E. Gooday seconded and the motion was carried.

The Secretary stated the result of the ballot for the Council, and the formal business of the meeting was declared by the President to be concluded.

The President then delivered his Presidential Address :—

PRESIDENTIAL ADDRESS.

By Sir THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S.

Every old campaigner, when moving off for an expedition into the wilds, has learnt the value of limiting his first march from headquarters to two or three miles, and then pitching camp, in order that, whilst still near his base of supplies, he may be able to repair unforeseen deficiencies in his equipment.

This Institution has now completed a short stage in the long history which obviously lies before it ; and, having completed the first dozen years of its life, we might take the opportunity of comparing our short experience with the hopes and ambitions that marked our inaugural meeting in March, 1914.

It is not easy, even under normal conditions, to predict the growth of a new institution. Small and obscure causes, as obscure as vitamins in food, may retard its growth, accelerate its progress, or even, contrary to paper estimates, cause its disintegration. But in this Institution we have the strange example of one which devoted to questions of petroleum in a non-petroliferous country, stands almost alone as a national organisation of the sort : it has grown in size without sacrifice of quality ; it has established its position as a standard of professional competence, and now holds

a definite position among the other professional institutions of a metropolitan kind; its Journal has outstripped its membership in a way that is not exceeded by any other body of the sort, partly because, even in countries where the very atmosphere smells of petroleum, there has been no similar association of professional men devoted to oil technology.

The facts are sufficiently remarkable, and to all, except a few, so unexpected, that they are worth reviewing. What is the subject of Petroleum Technology, which one never heard of before 1914? And still more, one might ask with wonder, what is a petroleum technologist? Geologists we all knew, and chemists and engineers; but is there such a thing as a man who combines enough of all three to constitute a definite professional species!

I doubt if among the twenty-nine Founder Members there was one, except Sir Boverton Redwood himself, who had any idea that our three constituents would ever hold together and develop as they have done. We were then accustomed to the growing specialisation of science and the formation of new institutions by the flocking together of birds of a professional feather. Some of us recognised the possibility of a federation of specialists sufficiently strong to deal with the central product of oil, and even they were more impressed by imperial necessities than by ideas of natural evolution. For one must remember that after 1911, and increasingly during the subsequent three years, when the Kiel canal was being deepened to accommodate super-dreadnoughts, the possibility of an international struggle was vaguely before us like an advancing barometric depression in the weather forecast. The result of the struggle obviously we knew must depend largely on the availability and use of every range of petroleum products.

Some of us entertained a hope of forming a strong federation of our three scientific constituents—a sort of concrete in which national sentiment was a prominent cementing medium; but to Sir Boverton Redwood, the Institution was to be, if not a chemical compound, at least a well-defined eutectic.

The idea of forming an Institution of Petroleum Technologists was a by-product of the conclusions which were impressed on certain members of the Royal Commission that investigated, under the chairmanship of the late Lord Fisher, the problem of utilising oil-fuel in the Navy. The witnesses who advised us were nearly all technical specialists: some of them told us of the engineering questions connected with the recovery, transport, storage and the utilisation of oil in prime movers; others told us of the chemical problems connected with the refinement of crude petroleum, the recovery of products from oil-shale and coal; others told us of the geological conditions under which

oil occurred, and therefore of the prospects of finding sufficient supplies within, and at accessible points without, the Empire. From a technological point of view all witnesses seemed to be utterly distinct and unconnected with one another. Among the members of the Commission there was similarly a sharp division into three classes. Yet the finding, the winning and the utilisation of oil formed one quest, inspired by the necessity of national safety.

In spite of the persistent claim of the venerable Institution of Civil Engineers that there were only two types of engineers, military and civil, there had sprung up distinct and formidably large institutions of mechanical, electrical and mining engineers. Federation of specialists was possible for particular and generally temporary objects; but the permanent union of geologists, chemists and mechanical engineers seemed to most of us to involve movement in a direction at right angles to that of natural evolution.

Sir Boverton Redwood's imagination enabled him to see beyond the horizon of most of us, and his persuasive enthusiasm brought us together. Of the twenty-nine Founder members who started the Institution nearly half have disappeared, but 800 others have gathered around the nucleus, and the growth of the Institution shows no sign of flagging.

When, through the vision of Sir Boverton Redwood, we were able, if but vaguely, to recognise the community of objects amidst the diversity of technological subjects, some of us still thought that an institution of petroleum *technology* might serve the purpose more surely than one of petroleum *technologists*. But our founder saw even further than the mere subject: he realised the necessity of establishing a recognisable professional standard, not merely in technological competence, but in that conduct and integrity which is expressed by etiquette.

Reference to Sir Boverton Redwood's inaugural address will show that he recognised the compound professional man as well as the separate specialists. I will quote his words:—

"The aims of our Institution are: (*a*) To enable technologists engaged in the petroleum or shale-oil industry to meet and to correspond, and to accumulate trustworthy information regarding the occurrence and production or winning of petroleum and oil-shale, the conversion of the raw materials into manufactured products, and the characters and uses of these products, together with their transport and storage. (*b*) To promote the better education of persons desirous of becoming professional consulting petroleum technologists, petroleum engineers, geologists, or chemists, and to elevate the professional status of those employed in the petroleum industry by setting up a high standard of scientific

and practical proficiency, and by insisting upon the observance of strict rules in regard to professional conduct."

Three of us were invited at the inaugural meeting to follow the founder with short addresses, and, as a set-off and corrective to my very narrow theme, the late Prof. Vivian Lewes backed the founder with a broader view. His words, too, are worth recalling:

"Specialisation should never be what it is so frequently is—a narrowing of knowledge into special channels: breadth of view must always be maintained, and general knowledge of the whole subject is essential to success. One of the charms of petroleum technology as a profession is to be found in the breadth of the interests to which it appeals: the geologist, the engineer and the chemist alike are needed in its manifold ramifications, and a grounding in all three subjects will show the trend of the student's inclinations and indicate the special lines to be pursued in his professional career. If geology appeals to him most, it is in this direction he should specialise, but engineering and the chemistry of the hydrocarbons must not be neglected, as a clear conception of the engineering difficulties to be overcome and the nature of the oil likely to be obtained are necessary to give full value to his powers of tracing the configuration of likely fields and his knowledge of the geometry of the anticline. In the same way, should either of the other main branches of the profession attract him, the general foundation should be well and firmly laid before specialisation is attempted, and I am convinced that it is only on such lines as these that complete success is to be secured. Common sense and adaptability will always make a useful man, but it is when sound training is added to these that you get the real master in his profession."

. . . . . .

"At first sight, those who have but a superficial knowledge of the subject may be inclined to think that the chemical side of the profession presents a far more restricted and less promising field than either of the others, but it is in this very direction that there is more work to be done, more to be learned, and perhaps the richest rewards to be gained."

If quantity of product be a fair test, our *Journal* shows that the last remark by Prof. Lewes was a reliable forecast.

So much for the ready-made petroleum technologist; but how was the class to be recruited; or, if a new species, how was it to be bred? For some other professions the universities and institutions of university rank provided suitable cultures—medicine and some kinds of engineering being conspicuous; but, so far, hardly the chemical engineer, and still less anything like a petroleum technologist.

In this matter Birmingham University, through the vision of Sir John Cadman, initiated the enterprise of breeding young petroleum technologists. Birmingham, in fact, moved in this direction before the Institution itself was actually registered and at a time when some of us—I dare not say, many of us—still thought that the new product must necessarily be but a sterile hybrid. Subsequent events proved us to be in error; for Birmingham has turned out men who have already made their mark in the world of petroleum technology.

When the special degree of B.Sc. for Petroleum Mining was inaugurated at Birmingham, conditions were not ripe for the long training which was required for a technological vocation based on a sufficiently broad scientific foundation. When long ago the universities wished to train students for the profession of medicine, they found themselves opposed by the established great Colleges of Physicians and Surgeons; and although public pressure became ultimately too much for them to resist, the strong position of medicine, protected by law, enforced a training of not less than five years. If other associations of professional men had similarly been protected, the B.Sc., Petroleum Mining, given only after a three-years' course of training, would not have been permitted, and the opportunity therefore would have been lost.

At South Kensington a systematic course, followed by a special diploma in Oil Technology, was not organised until 1914; and then the authorities of the Imperial College of Science adopted the bolder course of making it a four-year course after matriculation, like those for the similar vocational subjects of mining and metallurgy. The risk of prescribing this heavier course on inauguration was obvious, and as I was not then responsible for the policy at South Kensington, I feel free to state that the College was right in refusing to recognise a standard for the new qualification lower than that required for the old established diplomas in mining and metallurgy. However, those responsible for the institution of a new qualification at Birmingham were faced at the time with the custom already widespread in the Northern universities of granting a degree in vocational subjects on a three-years' training; and the alternatives seemed to be, either to do nothing at all to meet the requirements of the industry for young petroleum technologists, or to begin as they did on a scale that would permit of expansion afterwards.

This has since been done by extending the course to four years for honours' candidates, the fourth year being devoted to specialisation in one of the three main branches of petroleum technology. In breadth of training the two courses at Birmingham and South Kensington are now approximately similar. In methods of training

they differ in ways that are interesting to experts in educational methods generally. At both places the students enter with an approximately similar educational foundation—that required for the usual University Matriculation; and it may be well to give a brief outline of the average course at each institution before considering their differences.

At Birmingham the first year is devoted to pure mathematics, physics, chemistry and an introductory course in mechanical engineering. In the second year applied mathematics, more advanced chemistry and geology are taken, as well as mechanical and electrical engineering, surveying and petroleum technology. During their third year the students take chemistry, oil geology, and palæontology, geological surveying, mechanical and electrical engineering with petroleum technology. At the end of the third year the students must decide which branch of the industry they wish to enter, and the work for their fourth year is arranged accordingly. During the fourth, or Honours, year stress is given to the geological or to the chemical and engineering branches; but all students get lectures on tropical hygiene and in this year they spend some time assisting the post-graduate assistants on some problem of research.

At South Kensington a fair sample of the training given for the diploma of associateship (A.R.S.M.) is as follows: First year: Chemistry, physics and mathematics, some of the lectures in chemistry being given in German. Second year: Mechanics, applied electricity, graphics and geology. Third year: Geology in more specialised form; oil testing, refining and drilling; oil-shale mining; tropical hygiene. Fourth year: Topographical surveying, and more especially the geology of petroleum and natural gas; power generation; materials of construction and the economics of petroleum development. Research problems and special courses for advanced study are relegated to the fifth year required for the higher diploma of membership (D.I.C.); but this latter qualification cannot be taken until after the associateship has been conferred, and the associateship cannot be taken in oil technology until the student, in addition to his four sessions at College, has had six months' of approved practical experience, of which one-half at least must be spent on an established oilfield.

The students whilst at Birmingham get, on the whole, more of the practical side of oil technology than at South Kensington: they, for instance, get some training in a foundry, at the university power station, and with a full-size rig for drilling, as well as two vacation months at approved practical work. The South Kensington students are required to undertake their practical training

in oil refineries and on developed fields, at least a half of which must be done after leaving college. The A.R.S.M in Oil Technology is not conferred until the candidate can produce a satisfactory certificate of post-college experience on an oilfield, and that is necessarily somewhere abroad, often at a considerable distance from Great Britain.

There are, as I said before, important differences between the two systems of training, and some of these are worth considering. At Birmingham, as at practically all universities in this country, the ordinary practice of our secondary schools is carried on to higher stages by taking lectures in two or more subjects each day. Every new subject introduced to the university curriculum for graduation must necessarily conform to this system of training, for the complicated time-table of classes cannot now be unravelled. At South Kensington we still follow a system which was devised by Huxley for the old Royal School of Mines and has been nicknamed the "tandem" system; the student takes only one main subject at a time, and, at the end of each course in that subject, generally about half a session in length, he is examined. Each half-year's examination is thus for each subject, or well-defined part of it, a final examination. There is no such thing as a final examination in the higher grades of two or three subjects taken in one crushed week or so. It was this system of training and examination that made it impossible for the Imperial College to become, as the Haldane Commissioners hoped in 1908, an effective member of the University of London, so long as the University degrees were obtainable only by the group-system of final examination. The difficulty has, however, now been removed by the recognition of the College special training and its own examinations: the College thus preserves its individuality whilst taking the London degrees.

It would be going beyond the direct interests of this Institution if I attempted to discuss the relative merits of the "group" and "tandem" systems in university education. Each has some advantages as an educational method; but neither the College nor the University can now recast its system without closing the works for at least three years. At South Kensington, however, the tandem system has worked for over fifty years with results that, at any rate, cannot be described as unsuccessful; and, although the majority of our professors have been trained in the ordinary university system, not one among them, after a few years experience of our simpler life, would give it up: of all questions it is the one about which my colleagues are absolutely unanimous.

The other important point of difference between the training in petroleum technology at Birmingham and South Kensington

is due to the stage at which research methods are introduced. An introduction to research is formally made at Birmingham in the students' fourth year. At South Kensington the student is but rarely allowed time for research until after graduation. The difference is, however, less than appears on paper; for Prof. Nash, who is responsible for the training as it now is at Birmingham, carefully distinguishes between an introduction to research methods, and what is generally known as independent and original research. There is much to be said for the line which he adopts; for in training, as in the work of this Institution, we have to deal with the peculiar fact that we have no established oilfields at hand, and consequently students who take up petroleum technology are compelled to get this practical training generally in other and often distant lands.

Thus, unless the student gets some idea of how to tackle new problems before he leaves the university, he may never again for many years obtain an opportunity of undertaking research. On the other hand, until he has had practical acquaintance with the problems of a developed oilfield, his researches are not likely to lead to results of more than academic value. It is, however, often impossible for a student, after completing the usual period of engagement abroad, to break his professional career for a further period of training at the university. There is thus some justification for releasing him from ordinary class-work during his fourth year in order that he may be introduced, at least, to the methods usually adopted in searching for new lines of advance in technological methods.

As schools of training, Birmingham and the Imperial College are nearly as lonely as this Institution is as an association of petroleum technologists. The policy pursued at these two schools is of direct interest to the Institution, as we endow scholarships and prizes at both, and our Students' Section, which is markedly successful, is mainly recruited from both.

At the risk of extending this address to an undesirable length, I should like very briefly to refer to two instances of training in compound professional vocations, which are analogous in some respects to that of petroleum technology: they involve problems of a similar nature.

A group-subject which presents problems in training somewhat analogous to those that concern us is that of glass technology. The University of Sheffield has set an example in this direction, and the scheme of training required there for a qualification is worth studying.

The Sheffield University grants a diploma for non-matriculated, and a degree of B.Sc. in Technical Science, for matriculates, both

requiring normally three-years' training of university standard. There is also a four-year course, but it differs only from the other in providing for works' training sandwiched between and, therefore, in time, at the expense of the university work.

At the intermediate stage, glass technology is required in addition to pure mathematics, physics and chemistry. For the final stages the student's training is almost wholly vocational; for the classes in physical chemistry refer to the special problems of glass, and those in geology merely to the raw materials that are necessary in the industry. On the technical side the student deals with the technology of refractories and fuel, with some secondary training in mechanics, machine drawing, electro-technology and economics.

The Honours degree requires an additional year for those who take a first-class in the examination for the ordinary degree, and during this extra year students are expected to undertake an investigation into some problem of glass technology.

It will be seen that the ordinary degree course differs in two important respects from that required of oil technologists at the Imperial College: the course is more limited in range of subject as a natural consequence of its shorter term, and it requires no practical experience in works as essential before the conferment of a degree. The four-year "sandwich" course does, however, meet the latter point, and one would expect it to result in the outturn of more satisfactory products; indeed, one would like to see something of the sort to be made compulsory for all forms of degrees in vocational subjects, as clinical experience in hospitals is an essential part of the training of the graduate in medicine.

In the training of a petroleum technologist, as in the training of an ordinary chemical engineer, there may be differences of opinion whether the training should be of a chemical kind based on engineering, or whether it is better that the student should regard himself primarily as a chemist, and, on the basis of his chemical training, secure an opportunity for acquiring sufficient acquaintance with engineering principles and methods.

The outlook and opportunities of a chemical engineer are, however, of two slightly different sorts. In gasworks, in large oil refineries and in certain established chemical industries, the operations for which a chemical engineer is required are relatively stable from a chemical point of view; consequently, the work to be done is mostly of an engineering sort, being in the main, the design and maintenance of plant, which may be varied in capacity more often than in nature. In other chemical industries, however, the operations are continually changing with the progress of chemical research. New compounds of economic value are being

discovered in the laboratory, and new methods of manufacturing known compounds are being devised, with the result that chemical works of this sort have to be relatively mobile in order to face internal as well as foreign competition. A chemical engineer in works of this sort must necessarily think in the first place of chemical problems; but familiarity with processes of mechanical engineering is still necessary, although the dominating feature of his mental activity is more chemical than engineering.

Gasworks, like other public utility institutions, enjoy local monopolies; they have to turn out a product with certain specified limits of quality, and changes in their methods are thus relatively limited. Oil refineries similarly, but for other reasons, are comparatively stable: they are conducted on a large scale and change in method involve financial issues too large to be left to the ordinary chemical engineer. For the ordinary operations of oil refineries, therefore, a young man with a sound training in mechanical engineering, can acquire a sufficient knowledge of the chemistry of oils to be a useful officer, and ultimately to be a manager of oil-refining works. A chemist, with a specialised knowledge of petroleum, is wanted nevertheless, but more in the research laboratory attached to an oil refinery itself. The results of the research chemist can be translated into practice at leisure in an oil refinery as in the gasworks with the help of a staff of engineers.

In chemical works devoted to the manufacture of fine chemicals the need for translating laboratory into factory processes is more urgent, for otherwise the chemical manufacturer will lose ground and be pushed out of the market. The operations introduced to meet changes in the chemical market in such cases affect small parts of the works and involve relatively small financial outlay. The inspiration is chemical in the first instance; the translation to operations on a commercial scale can be done with a limited, though specialised, experience in mechanical engineering.

My brief review of what has been done by this Institution and of the way in which its interests have widened, show that our marching equipment is in fair order. The union of the three main types of technologists has shown stability; the publications of the Institution have found a real demand outside; professional standards have been established; the Institution has shown a practical interest in preparatory vocational training; and, with its assured financial stability, is now working out a scheme for granting assistance to research workers.

We have no legal authority, with powers similar to those of the General Medical Council, able to prohibit professional practice except by qualified specialists. Some institutions senior to this have done useful public service, however, in establishing

Associate-Memberships that require for the various branches of engineering the three essentials of age, scientific foundation and practical experience. We are working to the same end in the profession of petroleum technology. It is too early to boast of results, but after twelve years' experience, even with the interruption of the war, it is not, I hope, too early to review our aims, as I have attempted to do, for the purpose of testing our original policy. The purpose of this address has been partly to review the methods adopted for training young technologists. I hope it will be possible later for someone with sufficient field experience to review the results of the practical work of those who pass from the grade of Student to that of Associate-Membership.

Meanwhile, I feel satisfied that we have abundantly fulfilled the vision of our revered founder, in the quality of our publications, in the growth of membership, in taking an active interest in the training of young technologists and in the establishment of professional standards.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

Eighth Annual Dinner.

THE EIGHTH ANNUAL DINNER of the Institution of Petroleum Technologists was held at the Connaught Rooms, Great Queen Street, London, on Friday, March 26th, 1926. The Chair was occupied by the President, Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., who was supported by Mr. H. Barringer and Sir Frederick W. Black, K.C.B., Past-Presidents; Mr. Alexander Duckham and Mr. Arthur W. Eastlake, Vice-Presidents; Mr. Ashley Carter, Mr. E. Lawson Lomax, Professor A. W. Nash, Dr. W. R. Ormandy and Mr. William Sutton, Members of Council, and a large number of members of the Institution.

Among the distinguished guests present were:—Dr. F. A. Bather, F.R.S. (President, Geological Society), Engineer Vice-Admiral Sir R. B. Dixon, K.C.B. (Engineer-in-Chief to the Navy), Sir Arthur Duckham, K.C.B., Mr. C. S. Garland (London Section, Society of Chemical Industry), Mr. James Hamilton (Anglo-American Oil Company), Mr. W. St. D. Jenkins, C.B.E. (Director of Naval Contracts), Lieut.-General Sir George F. MacMunn, K.C.B., K.C.S.I., D.S.O., Mr. G. K. Menzies (Royal Society of Arts), Mr. J. W. L. Oliver, C.B., C.B.E. (Director of Naval Stores), Mr. G. Patchin (Sir John Cass Technical Institute), Sir Joseph Petavel, K.B.E., D.Sc., F.R.S. (National Physical Laboratory), Sir Adam B. Ritchie, Sir Robert Robertson, K.B.E., F.R.S. (Royal Society), Mr. H. Kerr Thomas (President, Institution of Automobile Engineers) and Lieut.-Colonel Sir Arnold T. Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O.

"THE KING."

The toast of "The King," proposed by the President, was accorded musical honours.

The President: Gentlemen, I have an announcement to make; I have a telegram signed "Garrett," which you will know as the name of a distinguished petroleum technologist; it is from that great oil centre Ploesti, and it says: "Please communicate Secretary of the Institution eighteen members of the Institution unable to be present in London dining together under the presidency of Frank Dabell.". I will read the reply drafted by

Mr. Ashley Carter. He says: "Please convey Dabell members of Institution dining together the sincere appreciation of the President and Members at the Annual Dinner for kindly greetings which they heartily reciprocate."

I have now a very pleasing ceremony to perform. You will remember on the last occasion of our Annual Dinner I had the pleasure of making a presentation of the Redwood Medal. These Medals are given through the generosity of Mr. Alexander Duckham to commemorate the memory of our revered and distinguished founder, Sir Boverton Redwood. To-night I have to present a second medal, and this time again it is for a paper on a subject of which the keynote is economy—the saving of our oil supplies. The medal is awarded to Mr. McCarthy-Jones for a paper which was published in the Journal in April, 1924, on "Electricity Applied to the Winning of Crude Petroleum, with Special Reference to the Yenangyoung Field." That field is on the East bank of the Irriwaddi River, and is for its size one of the most prolific in the world. The actual producing area is only about 2½ to 3 miles long and about half-a-mile wide. The paper by Mr. McCarthy-Jones describes, first of all, how the electricity was introduced. The scheme was introduced as long ago as 1914; it was then held up by the War, and finally inaugurated in 1922. The oil company which worked the scheme have worked for the good of the industry, and have taken care that in the scheme they have not been the only benefiters, but have also been benefactors; they have invited the other companies in the field to share in the electricity. The electricity is applied to the drilling of wells and the pumping of wells. Crowded together in a small area something like a thousand wells are to be found, and one can understand that not only was there before an enormous waste owing to the number of small units, but there was danger from overcrowding. The introduction of electricity has cleared the field to some extent of many small and dangerous operations, and has at the same time introduced a very effective and important form of economy in the utilisation of crude oil. The electricity is not only used for the direct field purposes, but also for the main line pumping station at the head of the 300 mile pipe-line to Rangoon. The application of electricity to the water service is also important, because the field is fairly high above the nearest river. It is also used for oil connecting and pumping stations on the field, for the workshops, the ropeway, the lighting and illumination of the bungalows, and for that most important industry in the East and in the tropics, ice-making. Altogether the scheme is of a very interesting nature from the point of view of the electrical engineer; it is interesting from the point of view of a petroleum

economist, and is described by Mr. McCarthy-Jones in a way that will call for the admiration of the Institution. The paper from the point of view of literary character, and generally in the way it was expressed, has easily secured the commendation of the judging committee. Mr. John Gillespie has kindly consented, in the absence of Mr. McCarthy-Jones to accept the medal on his behalf. It is especially appropriate that Mr. Gillespie should be able to transmit the medal, because Mr. Gillespie was with Mr. McCarthy Jones and associated with him in the design, development and the construction generally. If we could have divided the medal in any way, in order to recognise Mr. Gillespie's part in this work, we should have been glad to do so.

(The President then presented the medal to Mr. Gillespie.)

Mr. John Gillespie, in accepting the medal on behalf of Mr. McCarthy Jones, said : Sir Thomas Holland, I have the greatest pleasure in accepting from you on behalf of Mr. McCarthy Jones this medal, and I have equal pleasure in proffering to you in his name his warmest thanks and keen appreciation of the award which you have made. It is impossible for anyone to enter fully into the thoughts and the emotions of another man in circumstances such as these, but I know Mr. McCarthy Jones so very well that I can assure you without the slightest hesitation that he will very deeply appreciate the honour which you have conferred upon him. The paper, as you have said, dealt generally with the application of electricity to oilfield work, and more especially with the generation and application of electricity on the Yenangyoung field of Upper Burmah. As you have very kindly indicated, I had a close connection with Mr. McCarthy Jones on this scheme, and am therefore in a good position to judge of the merits of the paper which describes it. I have an advantage over Mr. McCarthy-Jones in that I can say some things which he as a modest man could not have said. I entirely agree with your appreciation of the paper and with the honour which has been bestowed upon it, and I desire to associate myself with you, Sir, and with the Council in the award which you have made.

It may be interesting to you to know that the scheme which is described in this paper has been a very complete success, and has given entire satisfaction to those who were responsible for its inauguration and its carrying through. Mr. McCarthy-Jones has three reasons for gratification with regard to this scheme. He knows that it was well designed and well carried through ; he knows that, as I say, it has given satisfaction to those who were most closely interested in it ; and he now knows that this Institution has marked the paper in which he described it with

the highest measure of approval which they can award. It may interest you to know that Mr. McCarthy-Jones is now in Bombay in control of the Indian Radio Telegraph Company, an affiliation of the Marconi Company. I have had news of him in the last few days; he is in excellent health, he is very busy, intensely interested in his work, and hopes within the next few months to communicate with the old country through the beam station which is presently under construction at Poona.

This medal has for me another association; it bears on its surface a very excellent medallion portrait of Sir Boverton Redwood, an old friend of many of us, the first President of this Institution, and the man who beyond all others did so much to raise the status of the Petroleum Industry, more especially on its technical side.

The President: I have also, on behalf of the Council of the Institution, to present the medal which is awarded for the best paper read before the Student-Members' Section. The medal this year has been won by Mr. E. Clark, who read an important paper on "Organic Theories of Oil Origin." As Mr. Clark's paper is to be read before the Institution in May, I am rather afraid that it might be premature if I said it settled this very interesting question. At any rate, the paper is regarded by the Selection Committee as well above the standard which is required to get the medal, and is in their opinion the best paper of the year. I have pleasure in presenting not only the medal, but a little document which I hope will be honoured.

(The President then presented the medal to Mr. Clark.)

Mr. E. Clark: Mr. President and Gentlemen, Sir Thomas Holland has given me a very pleasant, if somewhat difficult, task; the difficulty is to find words which express just what I feel. I thank him most sincerely for the generous terms in which he has referred to what, I fear, is a very ordinary paper. I assure you that I am deeply conscious of the honour which attaches to this medal, and I shall do my utmost to be worthy of it.

I know that I am speaking for the whole of the Students' Section in making mention of our very great appreciation of the keen interest taken in our affairs by senior members of the Institution. It is a very real encouragement to us when they attend our meetings, arrange works' visits, and generally manage to bring us into closer contact with the industry. The Institution gives us many such advantages, and assuredly we intend to give it of our best in the years to come.

The President: Gentlemen, the Committee in their task of judging the papers of the Students' Section found themselves to some extent embarrassed by the fact that the papers generally

were of very high quality. In addition to the one that Mr. Clark presented, which they decided to be suitable for the medal, they had a second paper which would have been good enough for the medal if Mr. Clark's paper had not been read in this particular year; and so the Committee recommended, and the Council accepted the suggestion, that a prize should be offered for the second paper, which differed from the first paper only in that it was second and not first. They have therefore made an award to Mr. Garlick for a paper on "The Chemistry of Petroleum." On behalf of the Council I present this letter to Mr. Garlick with the very greatest pleasure.

(The President then made the presentation to Mr. Garlick.)

Mr. H. S. Garlick: Sir Thomas Holland and Gentlemen, I had no idea that the Institution would regard my paper as it has done. I am extremely grateful and encouraged. Thank you all very much.

Lieut.-General Sir George F. MacMunn, K.C.B., K.C.S.I., D.S.O., in proposing the toast, "THE PETROLEUM INDUSTRY," said:—

Mr. President and Gentlemen, I rise to propose the toast of this important industry with a great sense of the honour conferred upon me, and also with a great sense of how inadequately equipped I am to do it justice. A soldier is proverbially clumsy of tongue, and his experience does not give him much technical knowledge of this great subject. As a citizen every morning I have to thank providence for the coming of oil to the world, and for all the amenities and comforts of every-day life.

Now, Gentlemen, as a soldier, as a member of one of the fighting forces, I know very well how to the Navy, and to some extent to the Army, oil is the breath of life. I know the air cannot be mastered without petrol. To me, as a Quartermaster-General, provision of the petrol and oil for the Army has been an every-day anxiety, and as an artilleryman I know how every gun clamours for its daily ration of oil and makes a great fuss if it does not get it. As one to whom the strategy of the Empire has always been of interest, I cannot help feeling that nature has perhaps paid England any way a back-handed compliment in the discovery of oil and oil fuel. You will remember that before oil came, in this one little island alone, or almost alone, was the first class steam coal to be found without which neither the warships nor the best liners can put up their greatest speeds, while we could sell it freely to our neighbours freely confident in the knowledge that it lost much of its power after a very few months in their stored reserves. With the coming of oil that extraordinary strategic

advantage has to some extent left us. It is a matter of great regret, therefore, that Nature has not yet compensated us for that by the finding of an enormous amount of oil in the British Empire and in those spheres of influence which are ours, though I know that since the War a great deal has been done in that direction. There are many here to-night probably who know better than I do the humiliating terms the Government has to accept in order to induce people to give us oil, which we would not have looked at for a moment if we had enough oil in our own dominions. When we consider that British capital and skill is developing so much of the oil of the world, it is certainly to be regretted that more of it is not in our own Empire.

What little experience I have myself of oil questions came to me when I went shortly before the Fall of Kut to Mesopotamia to organise the communications on the great rivers. I have a very lively memory of the great help we got from that wonderful organisation, the Anglo-Persian Oil Company. We even used their yard to put together steamers and build barges. We had, perhaps, the largest flotilla in the world on any one river, and not only the problem of oil fuel production, but the problem of the carriage of oil to various places, re-fuelling, and its storing in an undeveloped country, was a very anxious one. When the war was over, I had the honour of being Commander-in-Chief in that country for close on a year, and it may amuse you to know that I myself conducted in a small way an oil company with half a company of sappers under my command who were engaged in running an oil refinery in those still virgin fields below Mosul. We had what you might describe as a potstill, very much as you distil whisky in the glens of Ireland; but still we did extract enough petrol to run our lorries in that distant part of the world. I remember when the ever lamented Sir John Cowans came out on oil matters, I took him and his technologist to see where the fields were, and I remember their amusement in finding my half company of sappers and their illicit whisky stills.

There is very little more I can say that will interest you, but there is one point I would like to refer to, because it is a matter which interests me personally very much. That is the great effort towards the organisation of the welfare of the employees of all kinds which it seems to me the petroleum industry makes. We all recognise now that big business profits and great success lies in the provision of accommodation, the preservation of health, and also in amusements for the employees of all kinds. I understand the petroleum industry is quite in the forefront in developments of that sort. I should imagine that many of our older industries much wish that their predecessors had some better

knowledge of the great business principle of a good lay-out and good accommodation.

Gentlemen, I will now ask you to drink most cordially to the health and success of this great petroleum industry on which, indeed, the whole world depends.

(The toast was heartily received.)

Lt.-Col. Sir Arnold T. Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O., in replying to the toast, said: Gentlemen, I reply to this toast with considerable diffidence, for I am really a recruit amongst the veterans. Nevertheless, it is a real pleasure to reply to the toast which has been so eloquently proposed by my old friend Sir George MacMunn. He has told you how in Mesopotamia and latterly in India he had good reason to realise the dependence of the armed forces of the Crown upon the petroleum industry—on oil, that protean substance which, when it has at long last been located by the geologist, is transformed by the chemist into a bewildering variety of substances.

Sir George MacMunn is in a position to speak with knowledge on the progress made in welfare and other directions by the petroleum industry, for as Quartermaster-General in India he was responsible for the largest spending department of the Government of India, which is the largest single Government in the world. When the Inchcape Committee (the equivalent in India of the Geddes Committee in England) went out to India they had to enquire meticulously into every item of expenditure, and they ended up by congratulating him upon the efficiency and economy with which he had conducted his department. Business men, axe in hand, congratulated the military head of the biggest spending department on its efficiency and economy.

This is a young Institution. Though we are just twelve years old, this is only the eighth Annual Dinner—from which I conclude that, like other young people, we were not allowed to have a proper birthday until we were four years old. But the industry is a good deal older; it is roughly contemporaneous with the birth of the Darwinian hypothesis and the theory of the conservation of energy. It is as broad based as any industry can be. Not only do we find oil, but we transport it, store it, refine it, and sell it. It has not needed a Royal Commission to point out to us the desirability of selling our own products. It has not needed a Royal Commission to point out to us the advantages of large amalgamations of capital, and the importance of amalgamating as many concerns as possible into a single unit. All these things have been done by those pioneers of industry, business men, without any suggestions from Royal Commissions.

I believe the industry is destined to be even more important in the future than in the present. No nation is more dependent upon oil than we are; our maritime supremacy and our very existence at the moment depend upon it. Strong in the possession of the greatest coalfields in the world, we were a little slow to realise the national importance of large supplies of oil, and we started late in the race; and it was not until something like ten or twelve years ago that we realised that we were falling behind. But, thanks to the foresight and energy of the pioneers of the British oil industry, amongst whom I may be permitted to mention, with pride and indeed with affection, Sir Charles Greenway, whose absence to-night we all regret, the lost ground has been more than made good and Great Britain is to-day secure in the possession of vast resources of oil for all her industrial and national requirements.

Nevertheless, we must not blind ourselves to the facts. The estimated coal reserves of the world compare with the estimated oil reserves of the world, roughly speaking, as 100 to 3; and whilst we may have our own views as to the accuracy of the respective estimates of Dr. Jevons and David White, there is not much probability that the ratio will be substantially changed. The time may come, though I believe it is far distant, when we shall have to rely largely upon coal for motor spirit for cheap cars. If that time does come it will be due to the enterprise and genius of the members of this Institution; and this development will be as welcome to the petroleum industry as to the coal industry, for whilst there is an increasing demand for petrol and for oil products, there is always room for more aromatics, which we can reasonably hope to get from coal by scientific methods. In the meanwhile I cannot believe there is any rivalry between coal and oil; it is true a certain amount of oil is being burnt under boilers, but that is a transient and a passing phase of which none of us approve. The proper use for oil is in the internal-combustion engine. The industry owes its growth mainly to the internal-combustion engine, and the internal-combustion engine in turn owes its enormous development to the fact that this industry has placed in every part of the world adequate supplies for every conceivable form of internal-combustion engine. That, if I may say so, is our great achievement; we have placed the products of our skill within reach of everybody, whether in Persia or Patagonia, Iceland or Papua.

One of the most interesting paragraphs in the Report of the Coal Commission on the Coal Industry is that referring to the method of recruitment of colliery managers and directors of coal companies. It is hinted that the area of choice has been unduly

restricted, and that without family connections it is very hard for young men of good education and training to get a footing on the managerial or technical side, and it is hinted that certain deficiencies in the organisation and management of mines are traceable to this cause.

This is a complaint which cannot be brought against the petroleum industry: no industry is more careful in its selection of its staff, takes greater pains to get the right men to begin with, and to give them a chance of rising from office boy to chairman.

Another paragraph of particular interest to us is that in which the Commissioners suggest that British colliery owners do not sufficiently appreciate the importance of research, and express the opinion that some of the difficulties in which the coal industry is now involved are due to failure in the past adequately to endow and stimulate scientific research into the nature and use of coal and its derivatives. They add that research work can only be carried on efficiently if the organisation concerned is in a position to develop its programme logically and steadily, and steps should be taken to ensure that the organisations concerned are in a sound financial position, so that they can develop their programmes in a methodical manner over a period of years. This is not a complaint which can be made against the petroleum industry.

Remembering that the oil companies endowed general chemical research at Cambridge to the tune of £250,000 immediately after the war, and made a capital grant to Birmingham University of £125,000 in addition to subsidising this Institution to the extent of £1,000 a year, and that, in addition to all this capital expenditure, the leading oil companies maintain research departments costing no small sum, we may regard our record as an industry in the matter of research with no little pride, and I take this opportunity of recalling to you all the munificent gifts of £25,000 each to the Birmingham University by Lord Bearsted and Lord Cowdray. It is a matter of great regret to us all to know that Lord Bearsted is still indisposed, and I am sure we all wish him an early and complete recovery.

Finally, gentlemen, I would like to draw your attention to the comparative consumption of petrol, and of that ideal fuel for an internal-combustion engine—alcohol. The human internal-combustion engine has favoured it for some 10,000 years, and it is still supreme even now, in this age of oil. In 1920 we consumed in this country 1,000 million gallons of beer, wines and spirits at a cost of £469 millions; the same year we consumed 186 million gallons of motor spirit at a cost of £38 millions.

The brewers have us cold every time, but our distribution services have not been idle. In 1925 we consumed only 785 million

gallons of alcoholic liquors at a cost of £315 millions, as against 513 million gallons of motor spirit, costing £34 millions.

The national wealth has not increased during that period, and it is reasonable to suppose that people are beginning to realise that one can propel the human frame further on a pint of petrol than on a pint of beer, and are spending more on petrol and less on beer—and with every pint of petrol one gets an unlimited supply of fresh air.

The time is approaching when we shall sell as much petrol as the brewers sell beer. That will be a proud day for us in this industry.

With this comforting thought, gentlemen, I ask you to resume your potations and show that we know not only how to make, but to use, good spirit.

Mr. Herbert Barringer, M.Inst.C.E., M.I.Mech.E., M.I.N.A., M.Inst.Mar.Eng., in proposing the toast "Our Guests," said: Mr. President and Gentlemen, I have the honour to-night to propose the toast of "Our Guests." This is a very pleasing duty, and we are always delighted to enjoy their company on these occasions. In looking round at our distinguished guests, I feel that I cannot possibly do justice to this toast, but any shortcomings on my part I am sure will not detract from the cordiality with which you will receive the toast I am proposing. I will take advantage of the usual excuse of the lateness of the hour, and the anxiety of subsequent speakers to get on their feet, and, if you will bear with me a few moments, I will make a short reference to our guests.

We unfortunately have rather a long list of letters of regret. I do not propose to read those or to mention all the names, but I will mention a few. Mr. Stanley Baldwin has written regretting his inability to attend, as also has the First Lord of the Admiralty. Sir Oswyn Murray has also written; Viscount Cowdray, Sir John Cargill, Air Vice-Marshall Sir W. G. H. Salmon are also unfortunately unable to attend. Lastly, it is a great disappointment that Mr. Alan Cobham has written to say that he had fully intended to attend this dinner, but unfortunately by reason of arrangements which had been made he was unable to attend to-night; he wished me to express his sincere regret that he was not with us. I am sure he had something very interesting to tell us, and his attendance to-night would have been very appropriate, because without petroleum and the internal-combustion engine his marvellous achievement would have been impossible. I mention the word "petroleum"; but Mr. Cobham and his engineer supplied the indomitable spirit. I noticed that one

speaker at a recent reception mentioned that Mr. Cobham and his engineer were full of grit. That remark might be taken I think in more than one sense when he passed through that sand-storm, and it might also have been applied to his engine. I think it is a great triumph of that engine that it survived such a severe test and brought him through satisfactorily. I am sure we all rejoice at the impetus which this flight has given to the progress of aviation.

We know that since the introduction of aeroplanes our insular defences have been broken down, and I think it behoves us to consider seriously the matter of our air defence. We can rely upon the efficiency of our air pilots, but have we a sufficient number? I believe that is a point which we shall have to consider.

I will now refer to our present guests. We all welcome Vice-Admiral Sir Robert Dixon. I suppose there is no gentleman in this room who is responsible for a greater consumption of liquid fuel than Sir Robert; he has had the privilege and the responsibility of seeing the development of oil fuel in the Navy, and, as we all know, with such marked success. I am sure we are all pleased to see him with us again to-night.

We have to welcome also Dr. Bather, President of the Geological Society. Now, geologists are most important men; they tell us where to find oil, or, at least, they tell us where to look for it; I do not know that we always find it. Then we have with us Sir Joseph Petavel, who has rendered very valuable assistance in the National Physical Laboratory at Teddington. Then there is Mr. James Hamilton, of the Anglo-American Company; you all know how generously that company supported us, especially in our Student Section. We have Mr. Patchin, of the John Cass Institute; he puts technologists in the way they should go, and we are looking forward to very good results. We also have with us Sir Adam Ritchie of the Turkish Petrol Company. We have Mr. Menzies of the Royal Society of Arts; we are still enjoying their hospitality and hold our meetings in their very convenient building in the Adelphi. We have Mr. Kerr Thomas, the President of the Institution of Automobile Engineers, which is very closely connected with our Institution; they look after the engines while we look after the fuel. We have Mr. Jenkins and Mr. Oliver with us to-night; we welcome them very heartily; they are connected with oil fuel in the Navy.

There is one gentleman absent to-night to whom I must allude, as we greatly miss his cheery presence. I am referring to Admiral Stokes-Rees. You will all be pleased to hear he is in good health, but his medical adviser forbids him to keep late hours.

Now, gentlemen, I will not detain you longer, but I will ask you

to drink to the toast of "Our Guests," coupling with it the name of Mr. Garland, whom you all know very well.

(The toast was enthusiastically accorded.)

Mr. C. S. Garland, in responding to the toast, "Our Guests," said:—Mr. President, Mr. Barringer and Gentlemen, It will naturally have occurred to you to wonder why, when the long list of very distinguished gentlemen who are honoured to be your guests to-night was read out, the inadequate C. S. Garland should be asked to respond for such a distinguished company. The note which any of your guests who has to respond must strike is one of admiration for your Institution, and, for my own part, it must be one also of admiration for the blandishments of Mr. Ashley Carter, who is responsible for your being condemned to listen to me. He put it to me in that tactful way of his that so many of the really important people who were your guests were so rarely permitted to attend a public dinner without being called upon to speak that it was the wish of your Institution that they should on this occasion be allowed some relaxation, and that therefore it was the desire of the committee that a really insignificant person like myself should be entrusted with the task of replying for them. Naturally, I succumbed, and I bow to him in admiration for his tact, and do not fail to appreciate that with such a guidance your functions are so brilliant a success.

It must have been a great relief to all of us here to-night to hear from the mouth of so eminent an authority as Sir George MacMunn that there really is oil in Iraq, though it is true it is only in pot-stills. We were beginning to associate the gushing oil wells of Iraq with the bursting cornbins of Russia amongst the mirages produced like rabbits out of a hat by politicians, particularly at election times, and we can only hope that the oil pot-stills of Iraq will be as fruitful of benefit and solace to mankind as those other pot-stills used for other and, if I might say so in such company, more important liquids.

As one who is closely connected with other scientific societies which are in travail the whole of the time to find sufficient money to enable them to publish their journals, I must, I think, express my admiration for the way in which your journal is conducted and the fact that, although it contains so much matter of real importance to the industry, and to the scientific men connected with it, it is produced at so small a drain upon your resources. You are to be congratulated in making such good use of your limited advertisement space.

I am not too confident of the soundness of the advice which Sir Arnold Wilson gave with regard to the lessened consumption of alcohol. From the point of view of the petroleum technologists I

think it would be better that this liquid should be kept to its proper sphere. I have some recollection of reading that a large number of the records which have recently been made on motors and motor-cyles have involved the use of fuels for those internal-combustion engines containing a large proportion of alcohol, and I would suggest quite seriously that it should be the sacred duty of every petroleum technologist to drink as much of that material as he possibly can in order to prevent its competition with the other and legitimate product of the petroleum industry.

Finally, on behalf of your guests, I would like to say with what pleasure we see your encouragement to the students and your research scholarships, as well as the medals which you have instituted and which we have seen presented to-night with the accompanying envelopes, also represent a very kindly thought for the young men. We feel that you are building on a sure foundation for the future and continued prosperity of the industry. Nothing can be more important in a business which depends in such a large extent upon sound scientific work than to have coming forward a band of well-trained students and for them to receive that encouragement, the visible tokens of which have been before us this evening.

Gentlemen, on behalf of your guests, I thank you most sincerely for the delightful entertainment you have given us to-night, and on their behalf and on my own I wish the Institution of Petroleum Technologists every success.

Sir Arthur Duckham, K.C.B., in proposing the toast of "The Institution of Petroleum Technologists and the President," said :—

Mr. President and Gentlemen, I feel very honoured to be here to-night to propose this toast. I am very glad and I feel it an honour to be here, because I am the younger brother of Alexander Duckham, who is well known to all of you. I am somewhat diffident, because I am connected with that industry commonly known as the coal industry which at the present time is causing a considerable amount of trouble and discussion, and is not in a very happy state. If I may just, in introducing myself to you, remark that in life my brother has always been known as the greazy Duckham, whereas I have been known as the gassey Duckham, that does not mean that I talk a great deal or anything of that sort. I have the honour of proposing the toast of "The Institution of Petroleum Technologists"; I am going to be brief. This is, of course, the toast of the evening, because it is the toast of the Institution. I always feel that it is up to the man who proposes the toast of the evening to tell those present something about themselves. I have, therefore, extracted certain information

with regard to the Institution of Petroleum Technologists which may be of interest, which certainly we ought to mark, and from which we ought to take a lesson.

Your society was founded by Sir Boverton Redwood, as you know, in 1913 with 84 members. To-day you have over 900 members. That is a very fine record for any society founded so recently as that. Further, as we have heard to-night, you always seem to have a certain amount of money to spend on the various needs of your society. Further—and this I look upon as a very important thing—your Journal has a world-wide reputation. When one considers that your Journal has a circulation of 1300, that is a very fine circulation for a specialised technical Journal such as yours is; it is all the more wonderful when you consider that the British Empire owns about 2 per cent. of the total output of oil in the world, and one cannot but think that the Britisher must be going about his ordinary business and getting into those places where the plums are, as they have always done in the past, and making good not only as petroleum technologists, but in those other very useful services of transport and merchandizing, and in the other industries that are connected with petroleum.

Now, if I may just take a few minutes of your time on the technical side of the Institution of Petroleum Technologists, I would first refer to the great work which has been done on a matter which is important in any industry: that is standardisation. I was on the Committee of the Engineers' Standards Association, and I appreciated very much at the time the splendid work that had been done in standardisation. Standardisation must make for efficiency, it must make for improvement in the conditions in an industry, and I think the work which has been done by the Institution in standardisation has been very splendid; that it is splendid is shown by the fact that it has been generally accepted throughout the world.

Further, I would speak to you with regard to research. On that subject there are two things that appeal to me. When a young man comes to me and asks me what line of business he should go into, especially if he is of a technical turn of mind, I always say to him: Go into a business or go into some undertaking where there is a large margin for improvement, and one of the industries that I recommend them to consider is the industry of power or the production of prime movers. When we think to-day that in the output of electricity at least 80 per cent. of the heat value of the coal is absolutely wasted, it seems that there is a very fine opening for any young man with guts in him and brains in him, and with an intention to get on. In the same way, when you look at your great industry, when you consider that you

leave, as I am told, some 75 per cent. of your oil underground, it seems to me there is definitely a very great line for research and development in that industry. I am certain that such problems as that will receive your attention, and you will achieve splendid results.

Now, may I turn to a subject which was mentioned by Sir Arnold Wilson, a subject which is mentioned in the newspapers almost daily: the subject of low temperature carbonisation, a subject on which a great deal of money has been wasted, a great deal of futile experimental work done, and a subject with regard to which we are very little more advanced to-day than we were twenty years ago. Speaking to you as an Institution of Technologists, I would appeal to you on your research side to try and give some help to the people who are trying to solve this problem, by research work and technical work on those oils that are produced from coal. I am interested in the carbonisation and treatment of coal, and I have never yet been able to find any technologist who has been able to give me any true opinion of the value of coal oils, if we may use that expression. Sir Arnold Wilson, in his speech to-night, foreshadowed the very great value to this country that these coal oils might be; and yet the work that has been done on this subject is very small, and it has not been extraordinarily helpful.

Mention has been made of the report of the Coal Commission. I myself am especially interested in the coal report. We all welcome the recent coal report which has been produced under the very able chairmanship of Sir Herbert Samuel. If you have read it, I think you will agree it is the finest presentation of the coal situation which has ever been made. We have got to realise that to-day really the fundamental prosperity of this country depends on the proper solution of this great problem. I am certain that each of us in our sphere should do everything in our power to assist the Government, the miners and the mine-owners to come to a proper solution of this problem. So many of you men here are interested in industries and in products outside this country. I do ask that you should one and all give your attention to this very great problem, and if any of you can help in any way to the solution of this problem, I do hope you will give that service.

Further, speaking on the subject of the young people who are coming along, I have been very interested in this, one of our great troubles is to get absolutely first-class young fellows coming along into our businesses. You have a very strong student side to your Institution; I would ask you to strengthen it in any way you can. I would tell you this, that there is a great scope for any of you who will visit public schools to-day and tell the boys

in public schools the possibilities of life in your business. I have had the pleasure and honour of visiting quite a large number of the big public schools in this country, and I am sure that a great deal of work can be done by we who are industrialists who have made our way more or less in life, going and meeting these boys, and while they are young forming in their minds some idea of their future. We should tell them of the fun there is in winning through and of the prospects that lie before them in industrial life; I am certain you will be surprised at the reception you receive and the good that you can very easily do.

In my firm I have taken one public school, and mostly I recruit the young fellows coming into my office from that public school. Every year my managing director and my chief draftsman, the head of my technical department, visit that school and see students whom we see through the University if necessary, and then bring into our business as chosen students. I think that is a great way in which we are going to build up the army of young fellows who are coming on to take our place and to do better than we are doing, because they have had better opportunities.

In conclusion, I have to couple this toast with the name of your President, Sir Thomas Holland, of whom no recommendation of mine is needed. He has made his reputation as a great servant of the Empire. No man could ask for greater achievement. Further, as you know, he is a distinguished geologist, and has done more possibly on that side of oil production than any other man living. Therefore, I will give you the toast of the Institution of Petroleum Technologists, coupled with the name of your President.

(The toast was heartily drunk.)

The President, Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in replying to the toast, said:

Sir Arthur Duckham and Gentlemen, I have to thank you, Sir Arthur, for the very generous way in which you have proposed the toast of the Institution, and especially for the over-generous references to myself. I also have to thank the visitors present for the way in which they have received this toast. Sir Arthur has told you that he is interested in an industry that sometimes is regarded as a competitor of oil. We do not speak of our friends as competitors; we are glad, indeed, that they should in their own way draw as many lessons as they can from those who are engaged in the technology of our industry. Sir Arthur has made a distinguished position for himself in the world of coal, and especially of gaseous fuel. His brother, as he told you, is interested in another form of hydro-carbon which is generally of the liquid variety, known as a lubricant; but I can tell you that both of them are

distinctly from our point of view real solids. Sir Arthur Duckham would be welcome to us not only for his own reputation in the world of fuel, but especially because of the fact that he is the brother of Alexander Duckham, one of our Vice-Presidents. There is one point that he did not refer to in his own history. He told us he once was a member of a Commission on coal, and I think I may let you into what is not a secret to all of you, that he was the author of the minority report of that coal commission. If on that occasion the minority had been listened to instead of the majority, there would have been no necessity for the recent coal commission, for he was the minority member of the Sankey Commission to which we can trace more of our troubles than to anything in the form of neglect of research.

Sir Arnold Wilson this evening referred to the fact that this was only our Eighth Annual Dinner, and he wondered whether a young Institution which is over twelve years old was unable in its early years to undertake an annual dinner. I wish to assure Sir Arnold that it was not because in our youthful days we were unable to take solid nourishment, but because we were born almost immediately before the War, and the members of this Institution were, as you may expect, naturally in great demand in various services connected with the War. I should like, also, if I may keep on the personal line for a little while, to say it gives me exceptional pleasure to meet to-night so many of those who were associated with me during War activities. Sir Frederick Black, one of our past-Presidents, was sent out to India by a very anxious home Government to see that the care of munitions production, placed under a very young and inexperienced microscopic petrologist—a training obviously quite unfitted for anyone to take charge of munition factories—was running along right lines, and I can tell you that the advice that Sir Frederick Black gave us in India on that occasion was of real value.

On the other side, I am glad to have with us to-night an old friend whom I have known since his early days in the Army, Sir George MacMunn. At the time that I was responsible for the munitions supplied to the Armies East of Suez, Sir George MacMunn was Inspector-General of Communications in Mesopotamia. He was the foremost, the strongest, the most important of those whose duty it seemed to me, from my headquarters in Simla, was to lay complaints against the Munitions Department in India. But I always found that Sir George MacMunn's complaints when I visited him in Mesopotamia were not frivolous, but were accompanied by solid and useful advice.

Mr. Garland has given us a very interesting speech indeed, and he has criticised the Institution in a way which I hope will

be of use to us. He has referred to the fact that we probably get a very useful income from our Journal in the form of advertisements. It is a fact that we do allow a very limited number of select advertisements to occupy spare pages of the Journal, but I wish to correct the impression that he may have left on you by informing you that the sales of the Journal, over and above those issued to the members, have been the source of a very serious and important income to the Institution. It is an indication of the way in which the Journal, dull as it may seem, is appreciated among those outside the Institution and especially by those abroad. It is an extraordinary fact that in a country like this, where there is no oil to speak of seriously, we should have an institution in which the three forms of technologists are gathered together and are working to one end, and have organised an institution of a sort that is not known in any other country of the world, and that its Journal has really become authoritative and is in demand in those countries where, as I said last Tuesday, the atmosphere simply smells of oil. But Mr. Garland has given us a very useful hint; he has told us that we have an income from our advertisements, though it is small. We have a more serious income from the sales of our Journal, and that income would be increased if he allowed us to print his speeches verbatim.

I should like to take this opportunity of acknowledging the indebtedness of the Institution to the great oil companies that have from the beginning assisted us in our financial work. Sir Arnold Wilson referred to the way in which research in connection with oil problems has been endowed by the greater oil companies. The oil companies have in the same way devoted an annual subsidy to the Institution, and that subsidy has placed us in a position to be without anxiety regarding our normal expenditure. We have, for instance, this year found after very careful nursing of our finances, that we are in a position to devote annually a sum of money, which I hope will in later years be a larger one than it is at present, towards the endowment of research in connection with petroleum. There are many problems being undertaken in the Universities of the country that, either directly or indirectly, bear on problems of oil technology; with a standing committee which we hope to establish, these research problems will be investigated, and, so far as necessary within our means these researches will be supported. For our ability to do this we are to a great extent indebted to the contributions made by the oil companies.

I need not tell you about the progress the Institution has made; but I should like, as the hour is late, to take the opportunity of doing what an honest General, if not a good one, always ought to do, just to mention in despatches those who have contributed to the success

of the Institution during the year. I should like, first of all, to mention the devotion which has been shown by one of our members, who is a Vice-President and at the same time acting as Honorary Secretary, Mr. Arthur W. Eastlake, one of the founder members. To Mr. Adams, Chairman of the Finance Committee, we are indebted for a very careful control of our expenditure—a control exercised so carefully that I sometimes wonder whether we do not, in our absolute confidence in Mr. Adams, take his decisions as final beyond all possible question. So far we have found that in doing so we have been perfectly safe. I think the members of the Institution must realise from the Journal that is sent to them, to the tune of six parts every year, the enormous amount of work and energy devoted to it by Dr. A. E. Dunstan. Dr. Dunstan has, in addition to editing the Journal, gathered around him a very fine lot of young men to assist; he has inspired them to work in the same direction, and among other products in that direction there has been established an annual review of naphthology. That annual review is now becoming an important reference work. It is interesting, and to anybody like myself as President it is extremely important, because on turning it over last week, when I knew I had to face the annual meeting with a presidential address, I realised that all that could be said in any branch of petroleum technology had already been covered by Dr. Dunstan's review. It simplifies in a very important way the difficulties that are always before a president, who, if he is also President of three or four Institutions of this sort, sometimes feels that presidential addresses seem to come around as frequently as demands for income tax. I felt extremely thankful to Dr. Dunstan for that very able statement of the progress which has been made during the past year. Then those who attend our meetings must always realise how much we are indebted to our Secretary, Commander Stokes-Rees. He in his turn reports to us the faithful service which he gets from his staff.

Lastly, I know I shall get your support at this dinner in calling your attention to our great indebtedness to Mr. Ashley Carter. We all appreciate his organising ability, his wonderfully good temper, the extraordinary way in which he reports every detail and keeps us all up to the mark. We are indebted very much, indeed, to Mr. Ashley Carter for the careful way in which he arranges our dinner for us every year, and for the fact that he receives all of us very kindly, no matter what complaints we may make. I am glad to say we have, on the score of the Annual Dinner, never any complaints to make of him.

In conclusion, Gentlemen, I should like to thank you very much indeed for your interest in the Institution, as shown by the way in which you have responded to this toast.

Distillation of Mexican Crude-Oil Emulsions and Simultaneous Preparation of Asphalt Emulsions.

By Ph. J. de Kadt.

The various ways of working up crude-oil emulsions, described in literature and patents, depend upon preceding breaking.

The crude-oil emulsions (referred to as c.o.e.), as they occur in nature, are always of the water-in-oil type (w. in o.).

By physical (electric, filtration) or chemical means (addition of hydrophile agents) this breaking may be effected; distillation of the dry oil follows in any case.

One knows that even the slightest traces of remaining water will cause much trouble by frothing and despumating during distillation.

Moreover, the breaking of c.o.e., of which the oil phase is an asphalt base — as the Mexican, the Hurghada — leads to difficulties if the amount of water exceeds a certain percentage and thus many wells have to be closed untimely, none of the current methods allowing the c.o.e. to be worked up in its original state.

Investigations carried out at the Laboratory of Chemical Engineering of the Technical University of Delft during the year 1924, with the intention of preparing asphalt emulsions of the oil-in-water type (as used in road making and for roofing purposes) when starting from natural c.o.e. of the w. in o. type, gave rise to some remarkable observations, which might be the base of a quite new industrial method of working up those c.o.e.[1])

The c.o.e. from Mexico, with a high asphalt percentage, have been studied in this respect, especially the Zacamixtle and the Panuco c.o.e.

They are all of the usual type, water droplets dispersed in a continuous oil phase. The amount of water varies from some few per cent. up to fifty per cent. and more.

The oil itself is of the asphalt-base type and if such a c.o.e. be separated in its two phases by means of the Sharples-supercentrifuge, one gets the pure oil phase after 30-50 minutes turning at 35,000-40,000 r.p.m.

[1] *Dutch Patent* 26,782 Ned. Kl. 23 C.1.b., dd. June 25th, 1925.

A Zacamixtle crude oil thus obtained showed the following distillation-figures (Engler):—

	c.c.		c.c.
–100° C.	3·5	220°–230° C.	5·0
100°–120°	1·0	230°–280°	±2·0
120°–140°	0·5	280°–300°	0·0
140°–160°	2·5		
160°–180°	2·8		
180°–200°	2·4		
200°–220°	2·3		

Resuming :

0°–220° C.	15·0 vol. % gasoline and
220°–300°	6·6 vol. % kerosene

The amount of asphalt was ±20 per cent.

The original c.o.e. contained 48·7 per cent. water, dispersed as globules measuring 2-5 μ. in diameter; the water had an alkaline reaction (P_H=8·9).

The high amount of asphalt in this Zacamixtle oil allows its use for roadmaking purposes, and the author, being occupied with the preparation of asphalt emulsions of the o. in w. type, tried to inverse the original w. in o. c.o.e. into the o. in w. asphalt emulsion.

These inversions are known in literature, e.g. *Clowes* describes them very fully.[2]

The inversion of the c.o.e. by means of potassium oleate appeared to be very easy, but on applying o. in w. emulsion thus obtained to gravel or to diatomite bricks, the coagulated asphalt was too soft on account of the gasoline that was still in it, and so Prof. Waterman suggested the combination of inversion with distillation.

One knows that on inverting an emulsion one always passes a critical point, *i.e.*, the point where the mixture is neither to be characterised as an o. in w. nor as a w. in o. system. But the inversion of a c.o.e. by means of potassium oleate is a rather quick process and one can hardly observe that critical point. The hydrophile tendencies of the oleates of the light metals are too strong. So, combining inversion with distillation, this last operation is practically executed with a real o. in w. emulsion and renewed frothing takes place.

Instead of alkali oleates, the behaviour of other soaps was examined in this respect.

The attention was drawn to rosin soaps. The fraction, boiling from 280°-340° C. when Rosin G or H are distilled, is only partially saponified by solutions of alkali hydroxides. The resulting soaps possess a more feeble hydrophile tendency, *e.g.*, a complete inversion

[2] Clowes, *J. Phys. Chem.*, **20**, 407, 1916.

will not at all, or only very slowly, be attained. It seems that they have both a hydrophile and a hydrophobe (oleophile) character, probably on account of the amount of unsaponifiable matter of the rosin oil.

Applying this rosin soap to the c.o.e., the critical point can be fixed for a long time, *i.e.*, the c.o.e. is in an intermediate state, during which the gasoline and kerosene of the original oil can be totally removed by distillation.

That intermediate state can be observed, either by colour or microscopically. On saponifying in the c.o.e., as described later, one sees the black colour of the emulsion change into tobacco brown and this lasts until the process finished.

On the other hand, one can distinctly observe by microscope how the water-droplets, previously separated, now meet and join to long strings, between which one sees thin oil-layers.

The best way of acting is to dissolve the rosin oil in the c.o.e.; afterwards, while stirring the mass and heating it up to 40°-60° C., the caustic potash is added.

In general 1-1½ per cent. rosin oil will do, even 0·7 per cent. appeared to be satisfactory; the quantity needed only depends on the dispersity and the water percentage, *i.e.*, the total surface of the water globules, and increases with it.

Now the most remarkable fact is that on raising the temperature the gasoline escapes and when gradually heated up it is completely removed, while the mass in the still remains quiet and no frothing and despumating are observed.

When ±150° C. is reached, introduction of superheated steam is necessary, and the higher hydrocarbons leave completely on further heating; thus distillation is continued until the asphalt mass, remaining in the still, shows the properties suitable for the purpose for which it is required. Instead of superheated steam one may use, during the last period of distillation, a mixture of superheated steam with hot gases (air, nitrogen, hydrocarbons, etc.), or hot gases only.

When distillation is finished the mass still has the brownish aspect. One cannot compare it with a common distillation residue; under the microscope the field shows thin short stripes, relating to the rosin soap.

On adding 0·5-1 per cent. of a common soap (oleic acid, sodium hydroxide) to this residue at 60°-90° C., and diluting it with more water, under continuous stirring, a real asphalt emulsion—o. in w.—results, instantly fit for roofing and paving purposes.

The process was first carried out in a Pyrex glass apparatus, allowing quantities of 500-1000 grams. to be worked up, but afterwards a common iron semi-commercial still was used and

8 kgms. c.o.e. were easily distilled. The amount of gasoline and kerosene received approached nearly the theoretical value.

8 kgms. Zacamixtle c.o.e. with 48·7 per cent. water were mixed with 75 grms. rosin oil and 34 ccm. 2n. KOH.

7·5 kgms. of this mixture, corresponding to 3·78 kgms. pure oil, gave 700 grms. gasoline+kerosene=875 ccm.

The spec. gravity of the pure oil 0·89, the theoretical amount was

$$\frac{21{\cdot}6}{100} \times 3780 \times \frac{1}{0{\cdot}89} = 917 \text{ ccm.}$$

The fact observed has been stated and several times been proved and controlled. Only experimenting with synthetic emulsions of which we know exactly the composing phases in their physical and chemical behaviour can completely clear up this phenomenon.

Estimation of Unsaturated Hydrocarbons.

The following written communication has been received from **Prof. J. S. S. Brame**:—

In view of the very important actions to which Dr. Garner* has directed attention, further experiments were carried out to confirm or otherwise the possible removal of aromatic hydrocarbons by acid which alone, or in presence of paraffins, does not attack the aromatics, but which Brochet's work suggests may do so in the presence of olefines.

It was decided to employ 85 per cent. acid, as recommended by the writer in the discussion, and 88 per cent. acid, as recommended by Dunstan and others. The same cracked spirit (Cross plant) was used as in previous experiments. For the second series of experiments 10 per cent. (by volume) of toluene was added to the cracked spirit. The results of the parallel experiments are given in the table below.

	Cracked spirit.		Cracked spirit + 10% toluene.	
Specific gravity	0·751		0·762	
Aniline point, ° C.	40	..	31·8	
Shaken for ½ hour with sulphuric acid—				
Strength of H_2SO_4, % ..	85	88 ..	85	88
Vol. of recovered spirit, %	88·33	86 ..	91·33	87·3
Specific gravity	0·771	0·771 ..	0·785	0·787
Aniline point, ° C... ..	47·9	50·6 ..	36·7	38·7
Fractionated to original final boiling point—				
Vol. of recovered spirit, %	67·33	65·8 ..	68·6	63·66
Specific gravity	0·755	0·752 ..	0·764	0·763
Aniline point, ° C... ..	50·8	53·6 ..	42·2	45·4
Aniline point after 98% H_2SO_4 treatment, ° C. ..	57·2	57·2 ..	56·6	56·8
Estimated composition—				
Saturated hydrocarbons, %	62 87	63·34 ..	58·25	56·03
Unsaturated „ %	32·67	34·20 ..	31·40	36·34
Aromatic (as toluene) hydrocarbons by vol., % ..	4·46	2·46 ..	10·35	7·63

With each strength acid there is a large disappearance of toluene; with the 85 per cent. (assuming that the original spirit

Journ. Inst. Petr. Techn., 1926, **12**, 66–67.

contained 4·46 per cent. aromatics, giving a total with the added toluene of 14·46 per cent.) some 30 per cent. is lost; with the 88 per cent. the loss is over 50 per cent. These results appear to fully confirm Brochet's statement.

Attention may be directed to the large effect on specific gravity and aniline point of the presence of the products of action of the 85 per cent. and 88 per cent. acid.

Further experiments were made with the Cross spirit (no toluene added) by the I.P.T. method of fractionation and determination of the aromatics in the individual fractions. A summary of the results is given below :—

Range of fraction	Below 70°.	70–95°.	95–122°.	122–150°.	Above 150°.
Specific gravity ..	0·671	0·717	0·755	0·782	0·814
Specific gravity after 85% H_2SO_4 and distillation ..	0·656	0·719	0·747	0·770	0·806
Aniline point of same °C.	60	53·1	52·6	51·6	43·7
Aniline point after 98% H_2SO_4, °C...	60	54·2	54·8	58·2	60·4
Aromatics in fraction (by weight) ..	nil	1·27 (as benzene)	2·64 (as (toluene)	8·12 (as xylene)	20·54 (as xylene)

Apparently in this spirit the aromatic hydrocarbons are largely of high molecular weight. The low aniline point of the intermediate fractions after 98 per cent. H_2SO_4 treatment is suggestive of high polymethylene content.

STUDENTS' SECTION.

A paper by Mr. W. Crompton, A.R.S.M., entitled "Burmese Reminiscences," was read before the London Branch, Students' Section, of the Institution of Petroleum Technologists on January 19th, 1926. The paper dealt with the author's experiences in Burmah and was concerned mainly in prismatic compass and chain methods of stream traverses. Mr. Ashley Carter supplemented Mr. Crompton's adventures with those of his own when he was engaged in the Yenangyoung Field.

On February 16th, 1926, the Annual General Meeting was held. After the presentation of the Annual Report, Mr. H. S. Garlick delivered a lantern lecture on "The London Omnibus: Its Origin, History and Development." Sir Thomas and Lady Holland were present among the distinguished guests.

REVIEWS.

A TEXT BOOK OF GEOLOGY, for use in Universities, Colleges and Engineering Schools, by James Park. (Published by Charles Griffin and Co., Ltd.) 486 pages, excluding Bibliography and Index.

As an introduction to the study of geology we can thoroughly recommend this book—with certain reservations in respect of the last two chapters. It is the work of a close observer. The wide range of the subject is in general well covered. The author has spared no pains in the clear and sympathetic explanation of his subject. The text is supplemented by photographs and numerous simple diagrams. Lest the scientific terms employed should not be understood by the reader, the literal meanings and derivations are given in footnotes—a feature which we venture to think will be welcomed by many.

The crystallographic systems—not always made easy of comprehension—are described with admirable clarity. The last two chapters are, in our opinion, below the standard of the remainder of the book.

In the chapter on Economic Geology, for instance, we are surprised to note the omission of any adequate description of the occurrence of oil, a branch of the subject which has now assumed great importance.

The chapter on the Elements of Field Geology and Geological Surveying is inadequate for the intending professional geologist, who is led to think in terms of isolated outcrops, the particulars of strike and dip of which are to be carefully recorded in a field notebook.

The author fails to emphasise the importance—the necessity, in fact—of actually tracing individual beds, or at least group boundaries (by their physical features only, in the absence of outcrop) in order to determine detailed structure.

Trained Geological Surveyors will agree that this is far more important than scratching strike lines on outcrops in order to determine the exact direction—for a few feet—though perhaps it is as well for the young geologist to begin in this manner.

Again, the lath for accurate dip reading may be dispensed with by standing back from the outcrop and holding up the clinometer so as to cover a length of several feet—or more—of dip slope.

No mention is made of the use of the plane-table, which is now regarded as an indispensable instrument for extensive geological survey work in open country of which no suitable topographical maps exist. Nor is the leather map case as used by the British Geological Survey and others referred to. This we regard as an almost essential item of equipment.

The undoubted importance of recording field evidence *on the map—in the field*—is missed, the notebook being loaded with many data which should be put straight on to the map.

We note that the author's definition of minerals includes water and ice but excludes coal and oil.

We ourselves deprecate the use of foreign terms where perfectly good English words are available. Thus we prefer "rift" to "graben" (p. 163). Misprints, which are few, occur on p. 160, lobe for lode; on p. 394, vagueros for vaqueros, and on p. 24 accumulated for accentuated.

Most of these criticisms are from the point of view of the Geological Surveyor, and we are sure that the few defects indicated will not detract from the value of the book to a wide circle of appreciative readers, in addition to those for whom it is primarily intended.

S.L.J.

OILFIELD EXPLORATION AND DEVELOPMENT. Vol. II., Oilfield Practice. A. Beeby Thompson. Crosby Lockwood and Son, London. 1925. £3 3s. net.

In Volume II. of "Oil-Field Exploration and Development" Mr. Beeby Thompson's handling of the subject of "Oilfield Practice" is such that it cannot fail to become one of the first text-books on the subject.

It will be of the greatest utility both to the student and the expert in oil technology.

The author has succeeded, moreover, considering the magnitude of the subject, in attaining brevity without sacrificing lucidity. So essential is everything the author has to say that one must recommend a student to read every phrase with care—there are none wasted.

Mr. Beeby Thompson will be the first to admit that, with all his success in securing brevity, it would be impossible to treat the subject in all its phases within a book even many times the size of the present volume.

The student will find that the principles enunciated are a safe guide, and the method of application of these principles will be largely accepted by experienced oil men as satisfactory for the majority of the situations in which field managers find themselves; experience shows, however, that no single method can be applied to all fields, no matter what the situation be, similar problems require varying treatment. It would, however, be unjust to complain that all the varying methods have not been dealt with by the author, but at the same time one regrets that, whether for reasons of space or otherwise, the author has at times not carried to practical conclusions some of the operations he has introduced. The general quality of the volume indicates that such conclusions would have been of the greatest interest and would have enhanced its value as a text-book for the practical man.

The impossibility of dealing exhaustively in one volume (despite its proximity to twelve hundred pages) with the subject must be recognised, and it is to be hoped that at some later date Mr. Beeby Thompson will decide to let us have further literature on these matters.

There are parts where a knowledge of detail is shown which could only be acquired by personal contact with operations or by extreme keenness in the collection of study of such detail.

In the "Introduction" the author touches on the debatable point of the allocation of drilling costs to revenue—a point on which it will always be difficult to get companies to agree, their decision being guided by their policies and such are divergent.

The same adjective may be applied to the views of drillers on the types of joints, and sizes and makes of tools, referred to in the chapter on "Oil Well Drilling." There is perhaps no topic more likely to create diversion in a drilling camp than that of tools.

In the following chapter, "Subsidiary Oil Well Operations," the practical man will notice the absence of the protector usually attached to the lower end of the cementing tubes (Fig. 176); the omission of this protector has caused many warm expletives due to the choking of the tubes from contact with the well bottom.

Critics might pounce upon the author's statement on page 730 that "whilst no harm could result from the haphazard treatment of some (wells)," which

need coaxing into production, and have ample ground for their action. The author says, on page 799, that "there are fields where there is no water," but it must be the lot of few oil men to be so fortunate as to work in one. All will agree with the statement, on page 806, that "there are few, if any, oil fields where no water is encountered."

The chapter dealing with the "Location and Isolation of Oil Fields' Waters" is naturally of paramount importance to all interested in field work, and great care, knowledge and thought has been shown in the method of presentation; the chapter is worthy of the serious attention of all concerned. On page 809, where the question under review is the flooding of oil wells by water immersion, a feature pointing to the approach of water is a noticeable change in the temperature of the oil. A slight omission in not mentioning this, and the purpose of the C.I. disc (page 836), does not, however, detract in any way from the value of the whole chapter.

From an historical point of view, where the chapter deals with immense flows of hot sulphurous water struck in the western section of the Grosny Oil Fields, it perhaps would have been profitable to record that during drilling operations great trouble was encountered by the fact that the temper of bits and under-reamer springs were lost in an exceedingly short time after immersion into this water, and also that the wooden plug used in the shoe of water shut off columns was used here for the first time with great success, and afterwards used with similar success in other fields.

In the succeeding chapter, "The Recovery of Petroleum," the author deals, amongst other operations, with methods of production, revival of drooping wells, and control and protection of flowing wells. Here he very rightly states that every producing well is a problem in itself—the small modification in the arrangement of an installation may cause an immediate improvement in yield; he might profitably have added that the reverse also just as strongly applies.

On page 870, where dealing with choke nozzles at the base of the flow pipe in California, the author mentions that there are objections and difficulties to this practice. It is worthy of note, however, in Rumania some of the best wells, giving a minimum of sand trouble and a maximum of production, have various impedimenta at the bottom in the shape of lost bits, pieces of casing and suchlike accidental yet perhaps fortunate bottom chokes.

The value of the section of this chapter dealing with "Swabbing" cannot be over-estimated. The author rightly points out that, considered on a mechanical efficiency basis, the power expended on swabbing is very wasteful. He then proceeds by figures and facts to prove his contention. The reader will, however, appreciate, as does the author elsewhere in the book, that there are times when waste at a particular period ultimately spells profit, such as when competing with rival wells just over the boundary of the property under development.

The reader cannot fail to appreciate the trouble the author has gone to in drawing up the costs of production by baling, swabbing and pumping, and the same remark applies to the section on "Reviving Drooping Wells," with the seven sound practical reasons given for such drooping, each one of which is carefully and practically discussed.

In Chapter XVIII., devoted to "Oil Field Equipment," one notices with pleasure the absence of stereotyped illustrations of plant and tools usually very prominent in literature devoted to this subject.

The reader, however, will find an interesting section devoted to oil field dwellings, and others to power problems.

The closing chapters, entitled "Storage and Transport of Petroleum and "Natural Gas" respectively, deal with both subjects in a manner suitable

either for the student or the petroleum engineer seeking practical information.

One fact to be regretted is the absence of data relating to belting and wire ropes, both heavy items on the expense side of oil field development and of paramount importance in practically all operations.

The volume is to be recommended to all interested in petroleum technology.

C. D.

TIEFBOHRWESEN, FORDERVERFAHREN UND ELEKTROTECHNIK IN DER ERDOLINDUSTRIE. (Drilling and Production Methods and Electro-Technology in the Oil Industry.) By L. Steiner. Julius Springer, Berlin, 1926.

This book deals chiefly with the modern application of electricity to all phases of the drilling for and production of oil. It is a carefully written book based on theoretical principles supported by practical experience. The author does not drop immediately into what is clearly the main theme of the book—electric power and its development for oilfield requirements—but leads up to this part of the subject by dealing with the first principles of oilfield technology. Thus, the various drilling methods and systems in vogue to-day, as well as production methods, and the attendant auxiliary requirements that also demand power, are fully explained. Then follows the general discussion of the power requirement of each method and system, with requisite figures and calculations treated theoretically and, where necessary, modified from a practical point of view. Having thus cleared the ground, the question of the actual power station and its designs is left to the last part of the book. This is the correct sequence. There are not many books that treat of oilfield technology from a purely engineering point of view as this one does. A book like this should be useful to the student and the engineer on the field, giving the former a general idea of what the power requirements of a modern oilfield are, and the latter help in solving knotty problems of power that may crop up in the course of his daily duty. The book is, apparently, quite up to the latest practice, based, one would say, on European experience chiefly. Being in German, its use will be limited to a comparatively small circle of readers, unless an English translation is contemplated.

After a necessarily short, statistical and historical summary, there is a short section on geology in relation to oil, with a description of geo-physical methods. This section presents quite a good summary of its subject, and helps to make the book all the more complete from the student's point of view.

In a general introductory account of oil winning principles, one notes that casing methods are clearly based on Rumanian or Galician practice, as each string of casing in closely following the drill is only carried a short distance down. In many parts of the world, casings are, however, carried to much greater depths per string than those here given.

In the section dealing with drilling, the theory of the blow in the Galician system is discussed, and the author shows how the elasticity of the rods adds to the effectiveness of the blow. The diagrams on page 35 show this. A general description of the Galician (Canadian) drilling system is given. The comparative merits of driving the rig by steam, internal-combustion engine and motor are discussed, and a most favourable case made out for the latter. This is probably correct for an established oilfield with a ready source of electric power, but this is not always possible to realise, especially in the early development stages of a new field.

An interesting detailed calculation is given of the motor power required

for the operation of a Galician rig up to a depth of 1000 metres. In the result, the figures for three different operations work out as follow :—

1. Power for cleaning well after drilling	.. ..	51 K.W.
2. Power for pulling rods	.. ..	123 ,,
3. Power for moving casing	.. ..	112 ,,

It is shown that the power for actual drilling, being well within the least of the above, need not be considered. The author points out that as (2) is a constantly decreasing load, and (3) is a heavy power requirement of short duration, both can be supplied by drawing on the overload capacity of the motor, which is usually double the normal capacity. The calculation for (1) will, roughly, fix the normal h.p. of the motor—*i.e.*; say 60 K.W.

A full description, with illustrations of an electrically equipped drilling installation, is given. One of the advantages of the synchronous-alternating motor is that a sudden throwing off of the load does not cause racing as in the steam engine, but the motor merely runs at its normal speed. This, in cases of accident, is a notable advantage over other forms of power appliances. The author shows clearly, by means of the watt-meter diagrams, how each operation in the drilling of a well is automatically recorded (diagrams pp. 53-56). Calculations are given showing the advantage, economically, between electric power from a central station and the usual means of steam power either from a central boiler house or by means of a separate boiler at each well. This, naturally, works out very much in favour of the central electrical installation, showing according to the figures on page 61 a saving of M. 7896 and M. 14516 annually per well of electric power over the steam installation with separate boilers, and the central steam installation respectively.

The cable system is similarly dealt with. The system is described and the power calculations given. In this case (as compared with the Canadian system) on account of the higher speeds in use, the greatest power is that required for raising the cleaning baler. The respective powers for the different operations are :—

1. Cleaning	.. ..	102 K.W.
2. Drawing Tools	.. ..	49 ,,
3. Moving Casing	.. ..	63 ,,

In this case, therefore, the power required would be 100 K.W. normal, and is in excess of that required for the Galician rig. The power for lifting casing is much less than in the case of the Galician rig by assuming a much smaller speed of lifting. One may point an error on page 69 in the formula :—

$$Va = \frac{0.375 \times \pi \times 22}{60}$$

The result should be 0·432 and not 4·32, as shown.

One would, however, suggest as a result of the calculation, increasing the speed for pulling casing, by reducing the number of sheaves in the lifting blocks in order to use the motor for a short time to its full overload capacity. This point is not brought out in the example in question.

After dealing with the Raky rapid percussion system, the author goes into the various rotary systems of drilling. Electric power applied to the modern rotary rig by means of the alternate current synchronous motor is described. The power required for actual drilling is greater than with percussion methods, but the higher rate of drilling makes it more efficient. The power of the motor for rotary drilling varies from 75 to 120 K.W. In a calculation fully worked for a well drilling at 600 m., the power to move

casing works out at 128 K.W., and for drawing the pipes at 145. As the higher powers required for these purposes can be drawn upon from the overload capacity of the motor, a motor of 100 K.W. normal capacity is sufficient, as pointed out by the author. One may note here that 75 K.W. has been found sufficient in Burmah. The power for actual drilling depends not so much on the depth as on the character of the rock being penetrated. An interesting contrasting description is given of two systems of speed control—one using the ordinary alternative current synchronous motor in which speed regulation is obtained by inserting resistances in the rotor circuit, the other by using an alternate current series motor. By this means of regulation, only that current requisite for the load is taken from the main circuit. The only objection is that a direct current commutator is necessary, which requires a special fireproof house to avoid fire danger. The Hild automatic control is described. This was recently described in Mr. McCarthy-Jones' paper read before the Institution of Petroleum Technologists, and is very fully and elaborately described in the book under review. As is known, this is an automatic control of rotary drilling that has given satisfactory results in testing. Its utility lies in the quick response by the automatic raising of the tool from the cutting face of the stratum when a sudden change in hardness takes place and vice versa.

Various production methods are described in detail, such as by baling and swabbing, deep well pumps, compressed air, sunk pumps and shafts.

In baling and swabbing, the author correctly points out that only so much oil should be taken out as flows in naturally. He points out that the old-fashioned power consuming baling methods nevertheless permitted very exact control and regulation of water and sand inflow, not possible with the other methods. Some countries still practise this production method, and, here again, the author gives methods of driving the baling drums by electric power. One notes the baling drums shown are not of the handy compact type in use on the Russian fields formerly, where the barrel diameters were 4 ft. and 5 ft., thus permitting of quick descent of the empty baler. Power of motors for baling purposes varies from 50 to 100 K.W. Diagrams of electric working are given on pages 114 and 115. Interesting tables are given showing the fuel consumption in baling, comparisons being made as between steam and electric power—*e.g.*, using a baler 9 in. x 30 ft. at a depth of 852 metres, the fuel consumption between steam and electric power is as 14 to 4 (see tables on pages 120 and 123).

Discussing swabbing methods, the author points out the wasteful nature of this method in point of fuel consumed, which makes a well giving less than 100 tons a month unprofitable to work. Its use is forced on some fields like Galicia, where the wells are too deep for baling and the oil contains too much paraffin for the deep well pump.

The swabbing system is dealt with at great length both descriptively and mathematically, and those interested in this method will find all they require. The electrical installations for working it are fully explained and described. One may say, however, that, generally speaking, this part of the subject is of local interest, as the method is not in general use on oilfields. In discussing deep well pumps, the author enumerates its chief advantages—viz., useful for wells with small amount of liquid, small loss of light constituents, regular drawing of liquid from well. It is economical compared with the baler and swab. There is not the great variation in load, as found in baling and swabbing—hence simpler, cheaper installations and less fuel consumption (see curve page 203).

Motors for separately worked installations would be of 3 to 7 h.p. at 1500 synchronous revs. per minute. For working jerker line systems, motors

of 25 to 30 h.p. would drive 15 to 20 normal wells. He points out that electric power is more and more largely being applied to deep well pumping, to which it lends itself most suitably. In this case, he shows the advantage of electric power above steam engine and gas engine power. This, of course, is obvious owing to central station system, and hence the burning of either oil or gas to the best advantage. The description and careful exposition of the problem is of considerable interest. Thus he shows from actual practice that a motor driven pump gives a greater production than one driven by steam engine. This is due to the more regular working involving fewer breakages and stoppages.

The advantages of electric power generally are given on pages 193 and 194. Where a central power installation exists, these advantages are obvious. The trouble is that electric power can only be installed in a comparatively large scale and is not adoptable in the early life of an oilfield.

The air lift is briefly dealt with. He points out the limitations of this system, particularly in the necessity for a minimum submergence. Care is also necessary not to force the well. This was the fault in the early days of this method in Russia. He points out an advantage whereby the gas in the well can assist the air lift, and describes the packer jet method where this principle is applied.

The use of sunk pumps seems to be out of the region of practical application, as the author himself observes, and shows no advantage at present in the long run over the ordinary deep well pump. His description of experimental work in this direction is interesting. The same remarks apply to the hydraulic lift of liquid, the number of pipes and external apparatus making the system prohibitive. He describes the "Reda" Electric Motor with pumps which is lowered into the well in a pressure oil bath, but, at present, the whole installation is too delicate for practical use owing to the difficulty of keeping the pressure around the motor.

A more applicable sunk pump made by Siemens Schuckert is described, but no data is given of its working in practice. The advantages of a reliable apparatus of this description are obvious, as rods, tubes, derrick, hauling apparatus, etc., required in the case of the ordinary deep well would be obviated.

In discussing shafts and galleries, the author points out that with present producing methods, 40° to 60° of oil remain in the sand. It is probable that, on the average, this percentage is higher. He describes the two methods—one by means of which the oil itself is collected at the face and sides of the shaft and pumped away: the other, by which the oil sand is mixed and washed with hot water to recover the oil.

The fourth and fifth sections deal with auxiliary appliances in the oil industry, and, here again, the use of electricity is stressed, as *e.g.*, for driving surface oil pumps, refineries, cleaning oil, heating, workshops and for electric lighting. This is all dealt with clearly, and the most up-to-date methods and apparatus described and illustrated.

The sixth section is an extremely interesting one, dealing with the generation and distribution of the electric energy. It is impossible to enter into it in full in this review.

The author deals carefully with the principles involved in the design of the Power Station, the main factors being the power for drilling and propower for surface pumps, electric lighting, etc. He clearly points out the difficulties of arriving at an exact figure for the station power on account of the intermittent character of the energy demand. In many cases the unknown geological factor has to be considered and amply allowed for. The question of possible extension of the plant must also be allowed for.

The details of these questions, and how the author deals with them, are thoughtfully considered, and are worthy of careful study by engineers who have such work in hand. Under these considerations come the size and choice of generators, the character of current, voltage, the location of the station, choice of motors and method of driving, whether by gas motors, steam turbines, Diesel motors, etc., distribution methods, position and size of transformers.

The various types of motors in current use in present electric power installation on oilfields are described in full detail, together with the various apparatus used in conjunction, such as regulating devices, starting motors and transformers, switch apparatus and measuring installations.

Enough has been said to show that this book has been written with much thoroughness and care, and is a valuable addition to the literature of Oilfield Technology, particularly in relation to the use of electric power.

F. G. R.

CURRENT PETROLEUM NOTES.

Search for Oil in Eastern Alberta and Western Saskatchewan.—A report by Dr. G. S. Hume, of the Canadian Geological Survey, on his work in eastern Alberta and western Saskatchewan is being circulated in preliminary form, and copies may be had on application to the Director, Geological Survey, Ottawa, or to the Natural Resources and Industrial Information Bureau, The Canadian Building, Trafalgar Square, London, S.W. 1.

In 1924 a reconnaissance study was made of a large area in Alberta east of the Wainwright field. During 1925 a more detailed examination was made of the area in the vicinity of Battle river between range 24 west of the 3rd meridian and range 3 west of the 4th meridian. Following this detailed work a reconnaissance survey was continued over an area in Saskatchewan between latitude 52 degrees and the North Saskatchewan river and longitude 108 degrees and the 4th meridian. This work was carried into Alberta south of Wainwright to latitude 52 degrees and between the 4th meridian and longitude 211 degrees.

Descriptions are given of the geological formations, and data are presented in detail that have a bearing on the interpretation of the structural features—matters of very direct interest to companies planning a campaign of drilling operations.

Everywhere in the area studied the regional dip is gentle. Local tilting of the formations such as is found in the vicinity of Tit hills is believed to be due to superficial causes and has not relation to underground structure. Difficulty is encountered in finding strata that can be traced laterally to any extent, and consequently not as much can be done as might be desired in determining structure by the levelling of key horizons. Detailed levelling was possible, however, on an anticline on Battle River in the vicinity of the Alberta-Saskatchewan boundary. This is named the Ribstone-Blackfoot anticline. It has a north-east-south-west strike, and the crest lies in the vicinity of the exposure of the mouth of Ribstone Creek formation two miles south-west of the mouth of the Ribstone Creek, probably about section 12, township 46, range 1, west of the 4th meridian. The rate of dip on the north-western flank of this anticline is about 23 feet per mile for twelve miles in a north-west direction, and on the south-eastern flank 7 to 10 feet per mile south-easterly for an unknown distance.

The question whether such a broad anticline is likely to have been favourable to an accumulation of gas and oil is not easy to answer without drilling, even supposing other conditions than structure are entirely favourable. There is some reason to believe gas may be present, but in the writer's opinion a sharper fold would be more favourable for oil. A flow of gas was obtained at 290 feet in a water well drilled in section 24, township 46, range 1, west of the 4th meridian. It is thought that this gas flow must be derived from the base of the Ribstone Creek formation, and the fact that the well is located on the north-west flank of the anticline leads to the conclusion that this shallow gas is associated with the structure. If such is the case it would seem reasonable to suppose that a structure sufficient to cause an accumulation of gas at a shallow depth where seepage to the surface would be comparatively easy might also cause a much larger accumulation at depth provided strata of sufficient porosity to act as a gas reservoir are present under conditions favourable for the retention of the gas. From wells drilled in various localities in the Plains, sands of sufficient porosity to carry oil and gas are known to be present at the base of the Colorado and in the lower Cretaceous. There is no known reason to assume their absence at this locality, and the Benton shales form an effective cover for a gas or oilfield. Thus, although the structure as interpreted seems to be quite broad, it is the best known structure in this part of Alberta and Saskatchewan to test for gas, the closure of the structure in an east-west direction being several times that of the Wainwright structure in which oil and gas have been found. In the above discussion the merits of this fold as a cause of the accumulation of oil and gas have been considered only in relation to the fold itself. It happens that the crest of this minor fold coincides with that of a much broader regional one, the minor fold being superimposed on the larger one. Evidence for this broader regional folding is quite conclusive. It is a reasonable conclusion that the larger regional structure as well as the smaller local structures has had some influence on the accumulation of oil and gas, and since the tendency is for oil and gas to accumulate towards the crest of any structure, the crest of the major structure would be considered to be a favourable location. But since, as has been pointed out, the crest of the major structure coincides with that of a well marked minor structure, there is a further reason for regarding the minor anticline as a structure favouring the accumulation of oil and gas.

Dr. Hume discusses the chances for the occurrence of oil in this structural feature, and offers suggestions as to the location of test wells.

Alberta Oil Wells Show High Average Yield.—In comparison with the average production in other oil fields of the world, Alberta oil wells now producing show a high average. The Royalite Well, south of Calgary, in the Turner Valley field is producing 400 barrels a day of almost pure naphtha, while wells in the Wainwright field east of Edmonton are producing from 80 to 100 barrels a day. This compares with an average of 6·59 barrels in 298,915 wells in the United States in 1924, with an average of 55·53 in California, of 20·9 in Texas, of 8·32 barrels in Oklahoma, of 20·63 in Montana Rocky Mountain area, of 41·84 in Wyoming.

Alberta.—There are approximately 80,000 square miles in Alberta that have good petroleum possibilities according to a statement by Dr. Allen of the University of Alberta. Development work has included 96 wells completed and 15 being drilled.

Prospects of Canada's Domestic Oil Supply.—At the annual meeting of Imperial Oil, Limited, to-day Pres. C. O. Stillman, referring to the possibility of a domestic supply of crude petroleum, said: "This year, for the first time we can say there is some hope, although it is too early to speak with any degree of certainty. As a net return for upwards of four millions spent in the search for oil along the foothills of the Rocky Mountains, in the Arctic and across the plains of Alberta and Saskatchewan, we have one well that can be deemed successful. Royalite No. 4 owned and operated by Royalite Oil Company, a subsidiary of Imperial Oil, Limited, which came in during 1924, and which was brought under control in December of that year, has produced steadily throughout the past year up to the present at an average of close to 500 barrels of crude naphtha per day, and shows no apparent diminution.

Alberta's Oil Production.—A tentative statement on Alberta's production of petroleum in 1925 shows that the 1925 output in the province alone was greater than the production for all Canada for the year 1924. The bringing in of what is claimed as the world's richest oil well in the Turner Valley field south of Calgary, known as Royalite No. 4, was responsible for boosting the value of Alberta's production. This well has been producing on an average of over 400 barrels a day of almost pure gasoline.